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WITHDRAWAL OF WATER-POWER SITES AND CONSTRUCTION OF WATER-POWER PLANTS FOR MANUFACTURE OF NITRATES

HEARINGS

BEFORE THE

COMMITTEE ON AGRICULTURE AND FORESTRY UNITED STATES SENATE

281
727

SIXTY-FOURTH CONGRESS
FIRST SESSION

ON

S. 4971

A BILL TO AUTHORIZE THE DESIGNATION AND WITHDRAWAL OF WATER-POWER SITES AND THE CONSTRUCTION OF WATER-POWER AND OTHER PLANTS FOR THE MANUFACTURE OF NITRATES

Printed for the use of the Committee on Agriculture and Forestry

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WITHDRAWAL OF WATER-POWER SITES AND CONSTRUCTION OF WATER-POWER PLANTS FOR MANUFACTURE OF NITRATES.

THURSDAY, MARCH 16, 1916.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met at 11.15 o'clock a. am. pursuant to call, Senator Thomas P. Gore (chairman) presiding.

Present: Senators Gore (chairman), Page, Smith of South Carolina, Smith of Georgia, Gronna, Shafroth, Norris, Kenyon, Thompson, Wadsworth, and Johnson of South Dakota.

Present also: Mr. Frank S. Washburn, president the American Cyanamid Co., and Mr. George M. Schurman, 200 Fifth Avenue, New York City.

The CHAIRMAN. Gentlemen, the committee has before it this morning Senate bill 4971, introduced by Senator Smith of South Carolina, to authorize the designation and withdrawal of water-power sites and the construction of water-power and other plants by the United States for the manufacture of nitrates, and for other purposes. The clerk will insert the bill referred to in full in the record.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President at any time, in his discretion, may, by Executive order, designate for the exclusive use of the United States any site upon a navigable river, the improvement of which for purposes of navigation will make available at such site surplus water power over and above the needs for navigation. After being so designated, and until the designation is modified or revoked, every such site shall be developed and improved only in the manner and for the purposes authorized by this act.

SEC. 2. That the President may also at any time, in his discretion, withdraw from settlement, location, sale, or entry and reserve for the exclusive use of the United States any public lands of the United States, including the Territory of Alaska, whether within national forests or other reservations or withdrawals, which are valuable as water-power sites for the purpose of this act or which contain limestone, phosphate, coal, or other minerals or materials needed for the production of nitrates or other products as contemplated in this act.

SEC. 3. That the Secretary of Agriculture is authorized and directed to investigate and to recommend for designation or withdrawal such dam sites, water-power sites, and mineral or other lands as in his opinion will be necessary for carrying out the purpose of this act, and is further authorized to construct, maintain, and operate at or on any site so designated or withdrawn, dams, locks, other improvements to navigation, power houses, and other plants and equipment necessary or convenient for the generation of electrical or other power for the production of nitrates or other products useful in the manufacture of fertilizers and munitions of war: *Provided*, That all plans and specifications for dams in navigable rivers shall be submitted to and approved by the Secretary of War.

SEC. 4. That the Secretary of Agriculture is authorized to lease, purchase, or acquire, by condemnation, gift, or devise, such land and rights of way as may be necessary for the construction and operation of such plants and to take from any lands of the United States, or to purchase or acquire by condemnation, materials and minerals necessary for the construction or operation of such plants and for the manufacture of such products.

SEC. 5. That the products of such plants shall be subject to requisition by the Secretary of War or the Secretary of the Navy for military or naval purposes, and any surplus not so requisitioned may be sold and disposed of by the Secretary of Agriculture under such regulations as he may prescribe.

SEC. 6. That the sum of $15,000,000 is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, available until expended, to enable the Secretary of Agriculture to carry out the purposes of this act.

The CHAIRMAN. The committee will first hear from Mr. Washburn.

STATEMENT OF MR. FRANK S. WASHBURN, PRESIDENT THE AMERICAN CYANAMID CO. OF NEW YORK CITY. (RESIDENCE, NASHVILLE, TENN.)

The CHAIRMAN. Please state you name and place of residence.

Mr. WASHBURN. My residence is Nashville, Tenn., and my name Frank S. Washburn.

The CHAIRMAN. What is your occupation?

Mr. WASHBURN. I am an engineer, and my principal interest at this time is in the fixation of atmospheric nitrogen.

The CHAIRMAN. How long have you been an engineer?

Mr. WASHBURN. Oh, about 30 years.

The CHAIRMAN. How long have you been giving special attention to the subject of the fixation of nitrogen?

Mr. WASHBURN. Ten years.

The CHAIRMAN. Now, you may go ahead in your own way and make statements, and the members of the committee will ask any questions which may occur to them.

Mr. WASHBURN. When it was intimated that I might be able to give this committee some information which they did not possess upon the nitrogen problem, I had in mind possibly that the committee might not appreciate fully the importance of the nitrogen problem and its significance to the United States. Since entering the room and hearing your discussions I have reached the conclusion that the committee appreciates the importance of the problem and desires to approach it in an intelligent way, but is somewhat nonplussed to know what the status of the nitrogen industry is.

I think, first, I will lend myself to clearing up the minds of the committee as to what the nitrogen industry is, what it has accomplished, and those principal factors that to the informed, scientific world are developed and passed in the nitrogen industry.

First of all, it is well to bear in mind that an industry is not a discovery; it is not a thing that one discovers and immediately puts into use. One can make a mechanical invention, secure a patent on it, turn it over to a draftsman, develop it in the shop, and have it in use in a month possibly. But the nitrogen industry has been 16 years in its development. There was a long period of research work, involving an expenditure of about $1,000,000 before there was the least glimmer of commercial practicability.

It was a chemical and bacteriological problem, because the chief use of nitrogen is as a plant food, and an acceptable plant food is

a question of bacteriology, so that the early investigators, not employed for the purpose of developing any one man's idea, but for the purpose of covering the whole field, had to determine not only what would be feasible from the chemical and electrical standpoint but whether it would be acceptable as a plant food after they had developed the material.

In the carrying out of such a major process, there are literally scores of subsidiary processes, and while the principle by which the nitrogen of the air is fixed or made available is simple, carrying the principle into effect involves many processes.

To-day it is a practical, completed, well-understood, and highly efficient accomplishment. There is in use in this single industry to-day, which to Americans is almost unknown and carries a weird name, 1,000,000 horsepower, continuous, every second of the year, all going into the fixing of atmospheric nitrogen.

We have in the world one great center of power, Niagara Falls, greater than any other center of power that exists. If we could put to-day right along side of the present Niagara Falls a complete duplicate, those two Niagara Falls together would not develop enough power to equal the amount of power that is engaged at this very moment in the manufacture of atmospheric nitrogen.

The CHAIRMAN. Can you give us the distribution of this power as to countries?

Mr. WASHBURN. Roughly. There is in Canada about 30,000; in Germany, about 350,000 horsepower; in Norway, about 450,000; in Dalmatia, Italy, Switzerland, Japan, and France, I should think, 100,000 or 150,000, making approximately 980,000 horsepower.

Senator NORRIS. How much in the United States, did you say?

Mr. WASHBURN. None in the United States.

Senator SMITH of South Carolina. If you will allow me, is this table about correct as to the total of fixed nitrogen?

Mr. WASHBURN. Yes; that is correct for the cyanamid process, but that is just for one process. There are two processes; that is correct for the cyanamid process.

What has been obtained, economically speaking, is this: That the factory cost, under most favorable conditions, those which are not only theoretically obtainable, but actually obtainable in some parts of the world, everything, including overhead and superintendence and all that sort of thing inside the factory, but not including interest on the investment, for producing nitrogen, comparable to the nitrogen that is in the Chilean nitrate, is about one-third of the ordinary market price of the Chilean nitrate.

Senator SMITH of South Carolina. You mean to say that the factory cost is about a third of the selling cost?

Mr. WASHBURN. Of the selling cost of Chilean nitrate.

The CHAIRMAN. Suppose you put that in figures, giving the price in ordinary times.

Mr. WASHBURN. I am talking of Chilean nitrate at the rather low figure of $2.40 to $2.60 per unit of ammonia, which is the unit that is employed universally in agriculture, equal to 20 pounds of ammonia; and the cost in a well-placed, well-conducted cyanamid factory is 80 to 90 cents a unit.

Senator SMITH of South Carolina. Expressed in tons, it would be about $50 a ton for the Chilean nitrate?

Mr. WASHBURN. About $50 a ton, and for a ton of cyanamid material having the same amount of nitrogen it would be about one-third of $50, or, say, $17.

That is the result, one might say, broadly speaking, of 16 years of development.

Now, a word as to the course that this development is taking, because understanding the history of the development enables one to exercise his judgment as to what may be offered in the matter of future processes for future development.

So far as the cyanamid process is concerned—and its general history has been followed by the so-called arc process, or Birkeland-Eyde process—it began with a realization on the part of one of the great German interests (the most important of all the electrical interests in the world, employers of about 110,000 workmen in their factories) as early as 1900, that unless the world could have a new source of nitrogen, it could not keep pace with the growing food demands of the civilized world; so a separate company was organized and about $1,000,000 appropriated to conduct research work.

The CHAIRMAN. By the Government?

Mr. WASHBURN. No; by this single interest in Germany. They employed the finest staff of experts or scientific men that could be found, and they investigated every form and kind of fixation of atmospheric nitrogen that had ever been referred to or imagined, or that they themselves could develop, and they finally settled upon what is known as the "cyanamid process." Before making it known to the world they established at a cheap water-power in Italy a plant large enough to turn out material in a commercial form, and that was as early as 1906. That plant had a capacity of 4,000 tons of cyanamid, which is equivalent to about 5,000 tons of Chilean nitrate of soda.

The CHAIRMAN. Per day or what?

Mr. WASHBURN. Per year. And that was operated for a year or two to develop the commercial possibilities and refine the processes into commercial practicability before the process was made known to the world and before its owners disposed of any rights under it.

They found that the thing approached commercial feasibility in 1906–7.

The American history of the cyanamid process is that I went abroad about that time, in 1907, for the purpose of securing rights to what is known as the "Norwegian process," the arc process.

The CHAIRMAN. What process?

Mr. WASHBURN. A–r–c, another method of fixing atmospheric nitrogen, that proved, in a number of conferences and consultations with those who had developed and owned the arc process to be impracticable of application in the United States. We all understand that. The arc people understand it; it is just as well known among the informed as any professional subject is known in law or medicine. I then negotiated for the cyanamid process and brought it over here in 1907. A number of us put up $1,000,000 to conduct a commercial experiment. A small factory was built, and the process in the matter of the cost of production very much improved. The original guaranties as to cost we have almost cut in half by the developments of the America manufacturing staff and the research department of our company.

The CHAIRMAN. What is the style of your company?

Mr. WASHBURN. The American Cyanamid Co.

Mr. JOHNSON of South Dakota. Where is your factory?

Mr. WASHBURN. The factory was established on the Canadian side of Niagara Falls. The company now has a production of two and a half million dollars' worth of product per annum. The material is used almost exclusively as one of the ingredients of the so-called "mixed fertilizer" used in the United States.

Senator KENYON. Are you an officer of that company?

Mr. WASHBURN. I am president of the company.

Naturally, it has been necessary to conduct everything we have done with the utmost secrecy. As has been said, enough years have already transpired since the beginning to have outworn the patent period; and in order to enjoy a return upon the millions that are involved in the development of such an industry as this, things which the American investor and American people are wholly unfamiliar with, but which are practiced in Germany and France chiefly, one must be able to enjoy his patents through the natural period of their life. If patents are taken out on the day of the inception of the idea they become public and expire too early, and therefore it is universal in the history of the chemical industry that such matters are conducted in secrecy; in fact, there are special laws in Germany which safeguard that sort of property there, laws of which we do not have a counterpart in this country. For that reason as a people we are very much uninformed as to the present status and development of the nitrogen industry.

We have just had an example of the degree of perfection to which the industry has been brought in what has happened to Germany and in what the allied Governments are doing. When the European war broke out Germany had in store 660,000 tons of nitrate of soda, valued at something over $30,000,000. All powder, all military explosives, are based upon the use of nitric acid, and except by the winning of nitric acid from the atmosphere there is no other source of nitric acid except the Chilean nitrate, "Chilean saltpeter," as it is generally known. Germany, of course, was at once cut off from Chile. She had a supply of saltpeter sufficient to last her for a short period, a few months. Her powder bill grew rapidly, until six months ago Germany's powder cost was at the rate of $1,000,000 a day, average. She attained to that by the development—the sudden and quick development—of every form of securing nitrogen that was possible of development, but chiefly through the cyanamid process. She at once put into the cyanamid process alone 300,000 additional continuous horsepower. That is two-thirds as much as is being developed at Niagara Falls.

Senator KENYON. Has Germany developed her method of making nitrogen?

Mr. WASHBURN. Yes.

Senator KENYON. Has the method been published?

Mr. WASHBURN. Yes; knowledge of the whole process, so far as the fundamental principles are concerned, is public property through the publications of the various patent offices of various countries.

Germany has expended about $100,000,000 since the war broke out in the development of the nitrogen industry, all by the fixation

of atmospheric nitrogen. That was, as we feel, chiefly because she could not get Chilean nitrates. But the allies have in use in fixing atmospheric nitrogen for themselves pretty nearly half of the total amount of power in use in the world for this purpose, and they are now erecting all over Europe nitric acid plants to manufacture from cyanamid nitric acid, which is an absolute necessity for explosives.

So the point I wish to make is this, that the nitrogen industry is no longer in the experimental stage; it is not representative of anything that we can put into the laboratory in charge of an uninformed man, individually or together with associates, and have a practical process flower from it. It has taken the greatest scientists in the world, men understanding such things, 16 years to bring it to where it is a great, successful, reliable, extraordinarily cheap method of producing the most valuable single substance known to mankind.

For a moment, what is the importance of nitrogen? Its chief importance is found in two great human requirements—food and the means of national defense in times of war.

The CHAIRMAN. Preserving life and producing death?

Mr. WASHBURN. Preserving life and defending life.

The CHAIRMAN. Producing death?

Mr. WASHBURN. And the story of increased cost of foodstuffs and the relative records of the United States, we will say, and of Germany and others, in holding down the cost of foodstuffs and the general cost of living turn largely on the nitrogen fertilizer, for while we have advanced in this country about 80 per cent in our cost of foodstuffs Germany has advanced not much more than half that amount. The difference is chiefly because of the use of cheap fertilizers in Europe and the relative nonuse of fertilizers in the United States. It is not all involved, however, in the use of nitrogen fertilizer alone, because there are two principal plant foods and three that are in use, the two principal ones being nitrogen and phosphoric acid, and the third one, which constitutes only about 20 per cent of our fertilizers in this country, being potash. But it so happens that the nitrogen and phosphoric acid factors are locked together, and for any great economic advance of agriculture in the use of fertilizers in this country we must depend upon those two materials going forward together, and going forward together depends entirely upon the production of a large quantity of cheap nitrogen.

The fertilizer industry in this country, notwithstanding that our farmers pay twice as much for their fertilizers per pound of plant food as the German farmer, the use of fertilizer is per average cultivated acre only one-seventh of Germany's use. Germany's cultivated area—I might have taken France as an example, but the German records are a little clearer than those of France—is about 80,000,000 acres; the cultivated area in this country is about 32,000,000 acres—she has about a quarter of what we have, but she uses one and a half to twice as much fertilizer as we do. She produces, generally speaking, twice as much crop return per acre as the United States. And on that small area compared with the United States—the total area of Germany and England, you know, is only equivalent to Texas, with a population of 70 per cent of the population of the United States—she grows 95 per cent of her consumption of foodstuffs.

Senator PAGE. Is it not true that this great improvement in Germany has all taken place in the last 30 years, or nearly all of it?

Mr. WASHBURN. Germany was at first behind our own records, so far as the growing of crops was concerned, and Germany has gained what she has through three factors—intensive farming, the better selection of seeds, and through the use of artificial fertilizer, but to the latter should be ascribed not less than 50 per cent, and the French savants credit fertilizer with 75 per cent of that accomplishment.

Senator GRONNA. Might you not add to that a high protective tariff also?

Mr. WASHBURN. You mean in this country?

Senator GRONNA. No; I mean in Germany.

Mr. WASHBURN. That is a subject I am not competent to discuss.

Senator GRONNA. We will not discuss it.

Senator PAGE. We do not protect the fertilizers in this country.

Mr. WASHBURN. All fertilizers are free of duty.

Senator GRONNA. I am speaking of the price of the grain, the product.

Senator SMITH of South Carolina. You turned to me a moment ago when you said about "32,000,000 acres in cultivation in this country." I think it is approximately 60,000,000.

Mr. WASHBURN. Cultivated acres?

Senator SMITH of South Carolina. I think so.

The CHAIRMAN. There are 30,000,000 acres in wheat alone, and 100,000,000 in corn.

Mr. WASHBURN. I think if we take the acres that are cultivated and not the acre that is lying idle——

Senator SMITH of South Carolina. There are 32,000,000 actually cultivated in cotton alone.

Mr. WASHBURN. Which makes the disproportion all the greater.

Senator SMITH of Georgia. Your German figures you are confident are right—8,000,000 acres?

Mr. WASHBURN. That comes from the German statistics.

Senator THOMPSON. We certainly have more than 32,000,000 acres in cultivation in this country.

Senator GRONNA. In speaking of the cost of the products in Germany, to the effect that they are cheaper, would you include meats as well as grain? You know, of course, meats are much higher in Germany than they are here.

Mr. WASHBURN. I spoke of the cost of foodstuffs advancing in Germany about 50 or 55 per cent, while they advanced here about 80, and the general cost of living advanced in Europe about 40 per cent, while it advanced 60 per cent in the United States. That covered a period, as I recall it, of about 16 years.

Senator GRONNA. I was interested in knowing if that would apply to the price of meats or to the price of grain alone.

Senator SMITH of Georgia. I do not understand that you have said that the prices are cheaper there now than here?

Mr. WASHBURN. No.

Senator SMITH of Georgia. You have only said that the relative advance in cost was greater here than there?

Mr. WASHBURN. Yes.

Senator SMITH of Georgia. You attribute the lessened advance in cost there, to a considerable extent, to the development of commercial fertilizer.

Mr. WASHBURN. Yes; and that is reasonable and is borne out in light of the fact that the German acreage production of crops is about twice what our acreage production is, and is borne out, furthermore, by Germany's increase in crop production. For instance, I think it was in the period of 20 years that Germany increased her average yield of wheat 10 bushels an acre and we increased our average yield 2 bushels. In that period, too, we had virgin lands, and notwithstanding our leaving old lands and going onto virgin lands to make up for the decreased fertility of worn-out lands, Germany made an advance in that period in her increment of five times what we did, and so pretty generally through the various crops. Germany, while we were increasing our yield 1 bushel per acre, increased her yield about 5 bushels per acre, in that ratio.

Senator PAGE. I can give you in a moment the exact increase in the last 20 years.

Senator SMITH of Georgia. Really, that is not the most pertinent thing. We accept the proposition that it is most important.

Senator PAGE. Do you understand it is a more important thing in Germany than potash? I had supposed that potash was responsible for the immense——

Senator SMITH of Georgia. I said "most important," not "the most important."

Senator NORRIS. You said you went to Norway to investigate their methods of producing nitrogen from the air, and I understood you to say that you found that to be not practical for our uses here. Is that right?

Mr. WASHBURN. That is right.

Senator NORRIS. So the method you have adopted in Canada is the one pursued in Germany?

Mr. WASHBURN. The one pursued in Germany.

Senator NORRIS. What is the reason the method they pursue in Norway is not practicable here? And if you can, I wish you would tell us the difference in the two processes.

Mr. WASHBURN. I shall be very glad to. There are two processes in use in Norway. They are, first, the so-called arc process, with which we associate the name of the Birkeland-Eyde Co., and I heard Mr. Eyde's name mentioned in the committee before I appeared before you. Now, to show how little information the world at large possesses on this subject, the entire production of the Berkeland-Eyde process in nitrogen at this moment, with its great increase due to the demand of the English and French upon them for their product, is about double our production at Niagara Falls with our single plant. The cyanamid world production is many times what the arc production is, measured in the quantity of nitrogen produced.

The CHAIRMAN. What is the relative cost?

Mr. WASHBURN. In nitrogen, in the form of fertilizer, it costs about 50 per cent more to produce it by the arc process than it does by the cyanamid process.

Senator NORRIS. Is that the reason it is not practicable here?

Mr. WASHBURN. No. The answer is in the characteristic differences of the two processes.

The arc process requires five or six times as much power per unit of nitrogen produced as the cyanamid process. The requirements in nitric acid of our Army in the event of war are estimated to be 180,000 tons per annum—that is, of concentrated nitric acid. By the cyanamid process that would require 100,000 continuous horsepower; by the arc process it would require 540,000 continuous horsepower.

Senator SMITH of South Carolina. To produce 180,000 tons of concentrated nitric acid it would require what—what horsepower?

Mr. WASHBURN. One hundred thousand horsepower by the cyanamid process and 540,000 horsepower by the arc process.

Senator NORRIS. One of these processes is just really an improvement, is it not?

Mr. WASHBURN. They proceed along totally different lines.

Senator NORRIS. They do?

Mr. WASHBURN. Yes.

Senator SMITH of South Carolina. Mr. Washburn, before you leave that part, what is the minimum horsepower that could be utilized economically in the production of nitrogen by the cyanamid process?

Mr. WASHBURN. A plant employing 30,000 horsepower is an economical plant to conduct.

The CHAIRMAN. What is the minimum under the arc system?

Mr. WASHBURN. I should think 150,000, maybe.

Senator GRONNA. Is the arc process the only one used in the Scandanavian countries?

Mr. WASHBURN. No; for there is more produced by the cyanamid process than by the arc process.

Senator SMITH of Georgia. You have given consideration to the number of power sites in the United States that have more than 100,000 horsepower?

Mr. WASHBURN. Yes.

Senator SMITH of Georgia. What number are there?

Mr. WASHBURN. Of those power sites in the United States which, all things considered, are physically feasible for the development of 100,000 horsepower and over, for a nitrogen process, I do not know of any that are commercially feasible. Our own plans have been to develop in Canada where power is cheap. The powers of the United States are expensive to develop. I know of a power in Norway that cost only $25 a horsepower for all the hydraulic and electrical equipment necessary to enable an electric horsepower to be developed and delivered on the switchboard.

Senator SMITH of South Carolina. That includes the primary, as well as all the subsidiary powers developed?

Mr. WASHBURN. That figure applies to a particular power that was very cheap.

Generally speaking, Norway powers may be developed at $40 to $50. In the United States when we find $100 power it is cheap, and we run from that readily to $175. There is a good deal of discussion among engineers as to the American average. I have heard one of the most experienced engineers in the country fix the figure of $175 as our average.

Senator SMITH of Georgia. What power sites of 30,000 and more have you within your knowledge?

Mr. Washburn. If it were purely a question of power, and there was not involved in the problem the necessity of having that power close to the raw materials, and close to market——

Senator Smith of Georgia. Suitable for use for this process?

Mr. Washburn. Suitable for use.

Senator Norris. The raw material in the nitrogen is the air?

Mr. Washburn. That is one of the raw materials, but there is also required a very large quantity of limestone and a moderate quantity of coal.

Senator Smith of South Carolina. The limestone is the carrying agent which holds nitrogen in available form?

Mr. Washburn. Yes.

As to 30,000-horsepower sites, Senator Smith, I do not know one that is to be considered commercially feasible. I will tell you our story——

Senator Smith of South Carolina. You mean you do not know of one in the United States that is commercially feasible?

Mr. Washburn. Yes; and we get pretty good evidence of that in our plans for future development outside of the United States. The Birkeland & Edye people had an engineer in this country for three years who did practically nothing but search for water powers, and they never found any suitable.

Senator Page. What do you mean by "suitable"? Why can we not appropriate any water power of 30,000 horsepower unit profitably?

Mr. Washburn. Because the cost of development would bring the cost of the resulting product to a point where it would not be competitive with the product that can be produced in other countries and imported into the United States.

Senator Page. And is probably true that the demand for horsepower in the United States for other purposes brings the price so far above the cost of other countries that we could not afford to utilize it for nitrogen if we wished to?

Mr. Washburn. That is a factor, and is a factor in a number of situations; but chiefly our trouble in the United States is that those water powers which are favorably disposed in a matter of transportation of so gross a product as fertilizers are very expensive of development.

Let us look at this question of the cost of water power for a moment.

Senator Smith of South Carolina. Before you leave the cost—the Interior Department and Agriculture Department, principally the Agriculture Department—have indicated to me through my investigation, and in cooperation in the preparation of this bill, that we have in this country, under proper legislation, available water power for the development of atmospheric nitrogen plants.

Mr. Washburn. There are remote powers. There is a power in the northeastern corner of the State of Washington; there are some powers in the Sierras; there is a power in eastern Tennessee that can be developed so that power will be reasonably cheap; but the situations are impracticable—in some cases due to the necessity of particularly long and expensive transportation to the market and

on the raw materials, and because of the general absence of raw materials and a labor market.

Senator KENYON. You pay a royalty in Canada per horsepower per annum to the Government?

Mr. WASHBURN. No. We purchase our power from the Ontario Power Co., which is one of the large power development companies in Canada.

Senator SMITH of Georgia. You realize we do not meet our necessities at all so far as military preparedness is concerned by developing the power in Canada?

Mr. WASHBURN. I realize that. May I just for a moment develop this matter of power and give you the conclusion we have reached as to the practical method for the United States not only to have military preparedness, so far as insuring its powder supply is concerned, but also an economic blessing in time of peace?

Senator KENYON. May I ask you one question about your Canadian plant before you go into that? Have you any director of that plant in a foreign country—Germany, for instance?

Mr. WASHBURN. No; we have no foreign directors.

Senator KENYON. You have had, have you not?

Mr. WASHBURN. Yes; we have had.

Senator KENYON. With residence in Berlin?

Mr. WASHBURN. We have had a foreign director in Dr. Caro, who has been for many years my associate, and who has supplied Germany with her powder material, and is doing so to-day.

Senator KENYON. When did he cease to be a director in your company?

Mr. WASHBURN. It was after the war broke out. The German Government has prevented all correspondence and further communication between our German associates and ourselves here.

Senator KENYON. Is he still a director in your company?

Mr. WASHBURN. No; he is not.

Senator NORRIS. Mr. Washburn, might I ask you if the process you use there is held secret? Have you patents on it?

Mr. WASHBURN. Yes; it is covered by a cloud of patents; I should think there were 100 of them, and the general principles of the process are very simple and very well known.

Senator NORRIS. Does your company own the patents?

Mr. WASHBURN. Yes.

Senator NORRIS. There was something said a while ago by some one here to the effect that these patents had expired. What about that?

Mr. WASHBURN. No; there is no patent which has expired. I do not think there is a single patent, at least I can not recall a single patent which has expired on the cyanamid process.

Senator NORRIS. If anyone undertook to develop through this bill or otherwise in this country a factory, they would have to operate under your patents and get the right to operate from your company, would they not?

Mr. WASHBURN. They would have to operate under our patents. No means has ever been discovered for doing otherwise.

Senator KENYON. Suppose the Government would construct a plant as considered in this bill, would that have anything to do with your patents?

Mr. WASHBURN. The operation would be carried out under the processes covered by our patents. What right the Government would have to do that is a matter I have never given any consideration.

Senator SMITH of Georgia. If there was any necessity, we would do it and consider the question of liability afterwards.

Senator SMITH of South Carolina. I asked the department this morning as to the cyanamid process on the phone, and they replied that as to one of the processes—perhaps the main one—the patents on that would expire within a year. Are you acquainted with that? I will get a detailed statement as to that later?

Mr. WASHBURN. Our patents—those that make the process feasible and practicable, begin about 1910.

The CHAIRMAN. They are improvements?

Mr. WASHBURN. They are improvements.

The CHAIRMAN. You never let those patents run out?

Mr. WASHBURN. We never let them run out, and under the patents, as I was telling you, we have reduced our cost since we took up the industry about one-half. That cutting in half, the means by which it is done, is covered with patents and they date from about 1910.

Senator GRONNA. Is the arc process a patented process, Mr. Washburn?

Mr. WASHBURN. Yes; and I believe the patents expire in either two or three years on the Birkeland-Eyde furnace, and then there are a number of concentration methods that necessarily follow the furnace, and the most economical of them are covered by patents running quite a number of years.

Senator SMITH of South Carolina. I would like to hear from you how this Government is to avail itself, both in times of peace and war, of these processes?

Senator SMITH of Georgia. It is now just five minutes of 12. Do you not think, gentlemen, we had better take a recess until half past 12, and attend to the preliminary work of the Senate?

Senator BANKHEAD. I would like to ask a question. Do you know of any available power in the United States where nitrogen or nitric acid could be profitably manufactured? Is there not a site on the Tennessee River that would cover that whole question?

Mr. WASHBURN. The question on power sites, which the committee asked and what I tried to make clear in my answer, was taken to refer to the commercial development of the nitrogen enterprise carried out in the usual way with private capital.

The CHAIRMAN. To compete with imported material?

Mr. WASHBURN. To compete with imported material. But there is a means by which the Government can cooperate with private capital, and in effect make our water powers in this country as cheap as the cheap water powers of Canada and Norway.

Senator SMITH of Georgia. Let us now recess for awhile and discuss that after we come back.

The CHAIRMAN. The committee will now take a recess.

(Thereupon, at 11.57 o'clock a. m., the committee took a recess until 2.30 this afternoon.)

AFTER RECESS.

At the expiration of the recess the hearing was resumed, Senator Smith of South Carolina presiding.

Senator PAGE. Mr. Chairman, let me read into the record at this point, because it applies here, this statement:

In 1907 Germany had 43,000,000 acres sowed to wheat, barley, rye, oats, and potatoes, and harvested therefrom 3,000,000,000 bushels; while from 88,500,000 acres sowed to the same crops in the United States, American farmers harvested only 1,875,000,000 bushels. In other words, from less than one-half of the area German farmers harvested double the number of bushels.

Senator SMITH of South Carolina. And what are you reading from Senator?

Senator PAGE. From a speech I once made in the Senate. At that time I took pains to look up the facts in regard to Germany's efficiency. This table I took from page 13, Senate Document No. 176, Sixty-second Congress, first session, and I think it is reliable.

Senator SMITH of South Carolina. Well, Mr. Washburn, when we adjourned you were beginning to discuss the question of how we might avail ourselves of a sufficient supply both in peace and in war. We would be glad for you to continue. The main question here involved is the availability of our water power for the production of this element and relieving us from dependence on foreign countries.

Mr. WASHBURN. I appreciate that. I would like to take a moment to make a correction and to complete an answer to a question that was asked.

The cultivated area in Germany is about 125,000 square miles, and in the United States about 500,000 square miles. In making the conversion into acres this morning I dropped off a cipher, and the cultivated acreage of the United States should have been 320,000,000 instead of 32,000,000.

Then a question was asked as to the reasons that I found in my consultations with Dr. Eyde and his associates why the arc process was not appropriate to American conditions. I gave you one of them. The other is that the arc process is not a fertilizer process; it is a nitric acid and explosive material process. A fertilizer material was produced. Its production has ceased now, and it is very doubtful if it will ever be revived by the arc process. But the fertilizer that was produced was one suitable only to foreign conditions where the farmer scatters his material over the soil, strewing it by hand, and putting upon the soil at three different times each year three different plant foods, instead of mixing and applying them all together. That is what 50 cents a day labor can do compared with $2 a day labor in this country. We must make a mixture of our various plant foods, and the nitrogenous material runs through the drills with the phosphoric and the potash material. The fertilizer material produced by the arc process is not suitable for mixing; we have never been able to use it successfully in that way, notwithstanding many hundreds of thousand of dollars have been spent in endeavors to so change the character of the product that that could be done.

Furthermore, it is a low-grade product, and therefore its transportation is costly; it contains a comparatively small quantity of plant food.

Then it has this other very serious handicap. Now, we are getting into some of the intricacies of the fertilizer problem, and in that as in nearly every other human activity it is the detailed thing, the intimate thing, that is important, and not broad generalizations. Calcium nitrate, which is the fertilizer material produced by the arc process, is so quickly available in the soil, so quickly made use of by the plant, that the plant luxuriates under it and gets an excess of foliage with no adequate increase in the crop. Therefore it is necessary to use it in relatively small quantities.

The same is true of the use of Chilean nitrate. Both of those nitrates act as excitations to the plant, to give it, you might say, a good digestive apparatus, rather than true plant foods in themselves. And therefore, even though you might have an unlimited quantity of that material at a low price—which two conditions, as a matter of fact, do not exist—it is only in limited quantities that you could use the nitrogenous product that comes from the arc process.

Now, we have spoken of the reasons why there was abandoned in the United States any idea of using the arc process. Not only was that our own decision, but it has been the decision of others who have investigated it. First, its use of so much power that we could not find it. Practically it was not to be had. Second, the cost of the product. And for a moment, consider that the very cheapest power that could be secured in the United States would not be less than $10 per annual horsepower continuous, and at this figure the cost of power alone for producing a pound of nitrogen fertilizer by the arc process would be as great as the total cost of producing it by the cyanimid process. So we do not have to carry the comparison any further.

So we had those three difficulties, and then the further one that it is not a material that can be used universally, nor have we been able to discover any means by which it could be transformed into a nitrogenous product that could be used universally as a fertilizer.

Now, we come to the question of the solution of the problem. My interest in the question in Washington grew out of an invitation from the War Department about six months ago—at that time confidential in its nature—to suggest to one of the bureaus that seemed to be taxed with that responsibility, a means of guaranteeing a powder supply for this Government in the event of war. The feeling was it would be necessary for the Government to establish and build and hold idle a nitric-acid plant capable of producing 180,000 tons of nitric acid per annum. Germany's present use is equivalent to pretty nearly 300,000 tons of nitric acid per annum. This was two-thirds of the German war consumption that was considered to be a suitable supply for this country. It would be a great burden upon this country, and even after the burden had been shouldered of very doubtful utility and questionable as to its effectiveness to secure results, to build a plant as complicated as this would have to be, with water power, and the whole thing held idle for the 95 years of peace that we hope for as against 1 to 5 years of war.

(At this point Senator Gore entered the room and assumed the chair.)

Mr. WASHBURN. Therefore, out of these discussions there grew up the thought that if the Government should establish or aid in the establishment of a factory or factories which in times of war would

furnish the 180,000 tons of nitric acid and which in times of peace could be used for the manufacture of fertilizer, we would have transformed this military burden completely into a great economic advantage.

Now, any great economic advantage to the country is not to be found in producing a moderate number of tons of nitrogenous material through the fixation of atmospheric nitrogen for two reasons. The first is a commercial one. The fertilizer industry in this country lies under a peculiar burden. Notwithstanding our farmers pay twice what the German farmers pay for their fertilizer, there is no great money in the fertilizer industry. There is no great profit in it. The various great fertilizer concerns, and particularly the small ones, get only a moderate return upon their money, and no adequate return compared with the commercial risks they take. The farmer is furnished with his material, usually of very low grade, made up of nondescript materials, which are odds and ends gathered from every quarter of the country, and for that matter, from every quarter of the world, which must pay a high transportation cost to the mixing plants. There is a mixing charge, a carrying charge, and a big transportation charge to the farmer's town, his nearest railway station. The American Cyanamid Co. has been furnishing cyanamid as one of the mixing materials. The economic advantage that it might be to the country is entirely lost. It is only a small amount compared to the total, only one of the materials that are mixed with others. It comes out as a part of a very low-grade, high-cost fertilizer.

The CHAIRMAN. What percentage of the cost does it constitute?

Mr. WASHBURN. It constitutes of the total sales of fertilizer in the United States only 3 per cent of the nitrogenous materials alone, and only about 1½ per cent of the total fertilizer bill.

Senator NORRIS. That is, the nitrogen?

Mr. WASHBURN. The cyanamid nitrogen.

Senator NORRIS. That is the product——

Mr. WASHBURN. That is the product of the American Cyanamid Co.

Senator SMITH of South Carolina. You mean of the commercial products of the factory?

Mr. WASHBURN. Those percentages of the total amount used by the farmer at the present time in the United States.

Senator PAGE. The very large element of expense in commercial fertilizers is potash, is it not?

Mr. WASHBURN. No. The fertilizer——

Senator SMITH of South Carolina. Before you answer that question let me get this clear. You mean that the product of the cyanamid factory is only a small per cent of the ingredients that the farmer uses but not of the ingredients that the factory produces in the process of manufacturing cyanamid?

Mr. WASHBURN. I mean that the product of the Cyanamid Co. at this time, notwithstanding it has a large factory and is producing practically all of its material for the fertilizer market in the United States—I mean that the cyanamid product constitutes only about 3 per cent of the nitrogen used by the farmers.

Senator SMITH of Georgia. Of the United States?

Mr. WASHBURN. Of the United States.

The CHAIRMAN. You mean in the form of various fertilizers?

Mr. WASHBURN. In the form of various fertilizers. And it constitutes of the total fertilizer bill only about 1½ per cent.

The point I wish to make is that, whatever the merits may be of the nitrogen fertilizer produced in that way, it is lost in the great mixture, the great bulk of other materials that are high priced; that it can not affect the whole fertilizer industry or the use of the fertilizers in any great economic sense.

Senator SMITH of South Carolina. Right there, Mr. Washburn, I would like to say that we have arrived at a formula that is universal so far as fertilizers are used in the cotton belt. By experimentation we found that the same balanced fertilizer is about equally good for practically all the staple crops planted—oats, corn, all the cereals that we produce in the South, and cotton. It runs in the proportion of 8–2–2, 8–3–3, and 8–4–4. Those are the proportions in which the chemicals run: Eight per cent phosphoric acid, 3 per cent potash, and 3 per cent ammonia. By experiment we have found that from Virginia to the peninsula of Florida, as far as the cotton belt extends, with fertilizer mixed in those proportions you get the maximum result. It is a balanced ration for the plant, and we have found that is true even of our grains. That is about the standard—8–3–3. It is called "standard": 8–2–2 is low grade and 8–4–4 is high grade. Under the law of the State you can stamp it "low," "standard," and "high grade." That would be as the relation of 3 to 11 for the nitrogen. Of course, the ammonia runs a bit higher, but it is the same chemical formula practically.

The CHAIRMAN. Then it is not the cheap nitrogen in Germany that enables them to use fertilizer on such a large scale?

Mr. WASHBURN. It is very largely cheap nitrogen that enables them to do that, but they get correspondingly cheap their other ingredients.

Senator PAGE. What is the most expensive ingredient to-day, if it is not the potash?

Mr. WASHBURN. I will give you the figures. Our fertilizer bill in this country is about $175,000,000 a year, of which $75,000,000 is in nitrogen, or ammonia as we call it—the two terms are practically interchangeable—$65,000,000 in phosphoric acid, and $35,000,000 in potash. You see, potash is 20 per cent—75, 65, and 35.

Senator NORRIS. Would you mix those materials together in that proportion to make what we call a balanced ration?

Mr. WASHBURN. In that proportion of values, yes.

Senator NORRIS. Now, this nitrate factory—we will get nitrogen out of the air by developing the water power—supplies only the nitrate portion of that?

Mr. WASHBURN. Supplies only the nitrate portion; the other must come from other sources.

Senator SMITH of Georgia. But the nitrate portion is the most expensive of the three?

Mr. WASHBURN. Far more expensive.

Senator SMITH of Georgia. And costs $75,000,000 out of $175,000,000?

Mr. WASHBURN. Yes.

Senator SMITH of South Carolina. I think Mr. Washburn will bear me out that in normal times the cost of the nitrogen up to the present has been at least three-fourths of the cost of other material. Take our nitrate of soda, for instance. It is about 35 per cent nitrogen. We get $50 a ton for that. I am talking about what goes to the consumer. Phosphoric acid is 16 per cent. It will cost him about $12.50 per ton—16 per cent. Kainit, which is our form of potash, will cost us about $11; that runs from 12½ to 13 per cent potash. So you can see that, deducting your $11 and your 12½ and adding them, you have 18–5–4.

Mr. WASHBURN. Yes. If you come to make a comparison between the unit weight of the three substances, then the proportions of which you speak are correct. But when we come to speak of the total bill of the farmer, his total bill for nitrogen is not three-fourths of the total, but about seventy-five one-hundred-and-seventy-fifths, which is just 40 per cent.

Senator SMITH of South Carolina. You are taking the thing as a whole?

Mr. WASHBURN. Yes.

The CHAIRMAN. You were speaking of some other form when you said it was one and a half per cent. I did not quite catch that.

Mr. WASHBURN. I was saying that of the nitrogen produced by the American Cyanamid Co. it constituted about 1½ per cent of the total fertilizer bill in the United States. I am trying to bring out this feature, that it is not purely a question of the nitrogen industry or any particular process in order to secure this thing of economic advantage to the people of the United States; it is the meeting of peculiar limitations of the fertilizer industry to-day, and it can not be done simply through any old application of the art of fixing atmospheric nitrogen.

The CHAIRMAN. Is it your idea, then, that you have to cheapen each factor?

Mr. WASHBURN. No. Here is the point. Here is one of the limitations of the fixation of atmospheric nitrogen. None of the processes produces a material which can be used in unlimited quantities in mixtures. Cyanamid can not be used in unlimited quantities in mixtures, for the reason that if we attempt to use in our mixed fertilizer a large amount of cyanamid it reacts injuriously upon the other constituents, at least upon one of them—phosphoric acid. Therefore, while this country might cover itself with cyanamid factories and have an unlimited quantity of the product, as long as that product has to go into the ordinary mixture and follow the present methods of distributing the mixture to the farmers it would not have any great economic significance. It would be a profitable commercial undertaking, and it would end right there. I have already developed for you the limitation upon the calcium nitrate from the arc process.

Now, what is the answer? The answer is simply this, that the farmer has got to have, first of all, cheap nitrogen. Let us see. Sixty per cent of the cultivable area in the United States is devoted to grain producing, and yet the cost of nitrogen to the farmer in the United States is so great to-day, and the cost of fertilizers generally, that he does not get an assured profitable return from the use of fertilizers on grain crops. Therefore, broadly speaking, there is 60

per cent of the cultivated area of this country to which the application of fertilizer is prevented by the fact that it is not profitable under present costs.

What is necessary to bring the costs down? A number of things. First, a material that can reach the farmers' door cheaply. That means that it shall be a high-grade material. In the United States in 1910—there is a slight improvement each year—the average fertilizer used in this country was the 8—2—2. That means that for only 12 pounds of plant food the farmer had to transport and handle 100 pounds of material.

Senator SMITH of South Carolina. Up to 15 years ago the bulk of the sacked and tagged fertilizers was 8—2½—1.

Mr. WASHBURN. Yes; but now the transportation burden alone is a very serious thing. The cost of getting it over the muddy roads in the spring—in the South particularly—is a very serious thing. To have 88 pounds of perfectly useless material in order to have 12 pounds for the plant—that is a serious difficulty.

Now, after five years, four years of the most careful and expensive research work, there has been developed a material which contains 60 per cent of plant food—phosphoric acid and nitrogen. It is a chemical compound. It is one that has been known to the scientific and agricultural world for many years as the superior fertilizer par excellence, but its commercial production has been impracticable.

Senator SMITH of South Carolina. Is that ammonium phosphate?

Mr. WASHBURN. Yes; that is ammonium phosphate. Now, it has some contributory qualities. For instance, it can be produced in almost any ratio of nitrogen to phosphoric acid, as from 1 to 4 up to 1 to 1. A factory is now being erected in New York harbor which, together with the properties that are necessary to operate the factory, will cost between $5,000,000 and $7,000,000. In determining transportation costs it was found that there could be transported 1 pound of plant food in ammonium phosphate—from the factory on deep water, in New York, around to San Francisco or Seattle—for one-half of what it costs to transport 1 pound of plant food in the ordinary 8—2—2 goods from the ordinary mixing factory, to the farmer.

Let us see how that came out. In 8—2—2 goods there are 12 units of plant food, and $2 is almost universally fixed as the rail rate from the factory to the farmer. In other words, he pays $2 for transporting 240 pounds of plant food. We can transport 1,200 pounds around to the other coast for $5. That is at the rate of 240 pounds for $1. In other words, it is one-half as much burden upon the useful plant food to transport this new material from New York to San Francisco or Seattle as it is to take it from a fertilizer factory and distribute it to the farmer on the usual $2 freight rate.

Senator PAGE. Is that because so much phosphate rock or other cheap material is introduced in commercial fertilizer?

Mr. WASHBURN. It is chiefly because the materials that are available for use in fertilizers are so low grade in themselves, carrying so little plant food, that when you come to make the mixture you can only get a certain amount of plant food in the total weight.

Senator SMITH of South Carolina. In my State we have large deposits of phosphate rock. Practical experience taught us that by the same treatment with sulphuric acid we got from 14 to 16 per cent available phosphoric acid; and we found that was infinitely

cheaper than to try to extract any more of the phosphorus from the mother lode. It was a cheaper process.

Speaking of the cost of transportation, quite a number of years ago we stopped purchasing kainit and got the muriate of potash—which is the same thing, only the muriate of potash ran 18 per cent—and we found that in hauling by wagon and in the freight rate we cut it four or five or six times in two.

Mr. WASHBURN. That is a parallel case.

Senator PAGE. Is it not true that many of your fertilizer elements are introduced to liberate what is already in the soil?

Mr. WASHBURN. Not with that conscious purpose. It is true that there are certain things which affect bacterial life in a way which increases the assimilative power of the plant without actually giving it additional food.

Senator PAGE. I want to quote from an authority that Senator Smith of Georgia has great faith in; that is, Dr. Soule. At a meeting of our committee at one time he said:

> The virgin soil from Banks County, Ga., contains 6,400 pounds of nitrogen per acre-foot, 4,000 pounds of phosphoric acid, and nearly 15,000 pounds of potash per acre-foot.

Now, after 50 years of use of that soil it becomes 2,000 pounds of nitrogen, less than 2,000 pounds of phosphoric acid, and, in many instances, not over 6,000 to 8,000 pounds of potash. And he claimed to us that for every pound of cotton taken from southern soil 3 cents' worth of phosphorus was exhausted. I had supposed that the use of fertilizer was not only to improve the quality of the soil but to liberate the element in the soil. Now, here is a claim made, I think, that every bushel of wheat carries with it 27 cents' worth of phosphorus; every bushel of corn, 17 cents' worth; and every pound of cotton, 3 cents' worth. Every pound of cotton taken from the soil carries with it 3 cents' worth of phosphorus.

Senator SMITH of Georgia. Now, let us come back to the production of nitrogen.

Senator BANKHEAD. You stated a while ago that 12 pounds out of every hundred in the ordinary fertilizer is plant food. What is the rest of it?

Mr. WASHBURN. The rest is filler.

Senator BANKHEAD. It is a filler, but what is it? Is it sand?

Mr. WASHBURN. No. For instance, they will use a tankage with only 2 or 3 per cent of nitrogen, and the other 97 or 98 pounds will be extraneous materials that have no plant food in them at all. Then, there is some ground-up coal that is put in to balance the proportions. Sometimes ground limestone and various materials are artificially added as filler.

Senator PAGE. You speak of tankage. Now, tankage, in my judgment, is a very valuable fertilizer. If you take tankage that is made from bones and the meat of animals that have died from disease, and they are put into a digester and put under steam, and brought out and dried, that becomes a valuable fertilizer—just from what ingredients I do not know, but it must have some beneficial use, else it would not be purchased by those who are expert in buying fertilizer.

Senator SMITH of South Carolina. If the chairman will permit me, we are interested now in getting——

Senator PAGE. Just a word further, Senator. I know that all the tankage of a certain grade that can be purchased is easily sold at from $22 to $30 a ton.

Senator SMITH of South Carolina. It is away up above that now on account of the price of nitrogen—and it is a good fertilizer too.

Senator SMITH of Georgia. It has nitrogen and phosphorus both in it.

Mr. WASHBURN. Nitrogen and a little phosphorus. It is a very excellent fertilizer, but it is of very low grade. It involves a high cost of transportation per unit of plant food. The animal tankage which you speak of is quite a different thing from garbage tankage, but for the plant foods they contain they are both in excellent form.

Senator SMITH of Georgia. You have stated to us the importance of nitrogen for agriculture. What I want to hear something more about now is the development of a nitrogen plant in the United States.

Mr. WASHBURN. Now we come to this question: How can we establish a nitrogen plant in the United States? We have found that it has got to be done on a large scale. We have found, I take it, that it is important to produce something more than a simple nitrogenous material; in other words, a compound material of nitrogen and phosphoric acid.

Senator SMITH of South Carolina. Would it be possible to divide that and just let us know what are the chances of producing the simple nitrate or nitrogen? I want to know if it is not possible in this country to produce nitrogen independent of its combination with anything else.

Mr. WASHBURN. Absolutely so; and only in detail, as you might say, is the subject complicated by adding phosphoric acid to the nitrogen, and it gives the subject an economic value that entirely outshines every other consideration.

Senator PAGE. What benefit can there be in eliminating that other element that you speak of?

Mr. WASHBURN. There is no benefit in eliminating the phosphoric acid.

Senator SMITH of South Carolina. For one thing, if we can get an adequate supply of atmospheric nitrogen available for all purposes it would be highly important. I mix them on my own farm. I take, for instance, the Chilean nitrate, the phosphoric acid, and potash and get on my mixing floor and mix them. What I want to know is, can we get a substitute for the Chilean nitrate produced in this country? Is it practicable? Is it feasible commercially?

Mr. WASHBURN. Yes; it is, along these lines. In order to have the mind fixed upon something, let us take the situation at Muscle Shoals on the Tennessee River as an available power site. There is a great river needing navigation structures over the shoals, a distance of 30 miles, which are practically nonnavigable now, and disconnect the upper reaches of the river, navigable for 500 miles from the lower reaches of the river. On either side of Muscle Shoals hundreds of thousands or even millions of dollars have been spent by the Government for the purposes of navigation.

The CHAIRMAN. That is in the United States?

Mr. WASHBURN. That is in the United States.

The CHAIRMAN. Do you mean there is a stream in the United States that is not navigable? [Laughter.]

Mr. WASHBURN. Very few that are not navigable legally, but many that are not navigable in practice.

Those shoals are on the Tennessee River in Alabama. Of course, the Tennessee River covers a great many States.

Senator KENYON. How much has the Government spent to make that navigable down there?

Mr. WASHBURN. On the whole of the river?

Senator KENYON. At the shoals?

Mr. WASHBURN. At the shoals? There is a lateral canal now that is called a navigation structure, but which is wholly inadequate to any modern use, that has cost the Government anywhere from four to five million dollars, and its existence absolutely prevents the development of any power there.

Senator KENYON. It is of no use at all for any purpose?

Mr. WASHBURN. I should say not; I think it is pretty generally conceded. Now, at this point, to give modern navigation facilities, which consist of locks and dams, it has been proposed by the Army engineers that there shall be two high dams, one 102 feet and the other 40 or more feet in height. Dam No. 2 is the one 102 feet in height. Here there can be developed continuously 100,000 horsepower. It will cost the Government for Dam No. 2 and its locks, the substructure, the power house, and the installation of 150,000 horsepower hydroelectric machinery, $15,000,000. The immediate contribution that the Government should make toward a nitric acid plant at that point would be $5,000,000. So that if the Government should provide power at that point and make its contribution toward the nitric-acid plant there would be involved there an expenditure by the Government of $20,000,000.

Senator KENYON. What do you mean by this contribution? It is a contribution to somebody else?

Mr. WASHBURN. No. It is a contribution toward a nitric-acid plant to be used in times of war; it would not be used in times of peace, and therefore would bring no returns.

Senator KENYON. But it would still be a Government plant?

Mr. WASHBURN. It would still be a Government plant. Now, private capital in order to avail itself of the water power in the manufacture of fertilizer and some nitric acid in times of peace, producing 20,000 or 30,000 tons of nitric acid in times of peace and the equivalent of about 2,200,000 tons of 8–2–2 goods, would have to expend from $20,000,000 to $24,000,000. Including working capital, it would have to be about $24,000,000.

Now, it is believed that if the Government will furnish power at that point to private interests at 3 per cent of the cost of the power used, thereby having a return of its ordinary interest rate, private capital can then afford, and it would be to its interest, to make its investment of $20,000,000 to $24,000,000 and conduct a fertilizer industry at that point.

Let us see what are the merits of this plan. The fertilizer would be an ammonium phosphate, which would have the great economic advantages that we have been discussing. The factory site is right on the edge of—in fact, almost in the phosphate fields of the Tennes-

see. Coke can be had very cheaply from Birmingham, which is just to the south. Limestone of superior quality is close at hand. The plant would be on the Mississippi River drainage, and if one looks at the map where there is marked the value of farm products it will appear that, with the exception of the southeast and in the cotton region, to which we are also very close, almost at the center of gravity of the use of fertilizers, the rest of the great production of farm products is on the Mississippi River and its tributaries. The labor market is most excellent for the conduct of such a business as we are speaking of. The enterprise would add to the quantity of fertilizer now used in the country between a third and a quarter.

And what would the Government have secured? The Government would have secured at an interior point, believed by the War Department to be safe from invasion or attack, the only means of providing a powder supply by which this Government could conduct a defensive war. There the nitric acid could be produced. Now, as to the cost. In times of war the Government would have nitric acid at the cost to the producer plus such an additional amount as manufacturer's profit as the Secretary of War, we will say, in his good judgment may from time to time think is reasonable and proper. There would be no other hold upon that feature of it. In times of peace you have a great quantity of fertilizer right at the point where it is required, and accomplish this at such cost for fertilizer that our 60 per cent of cultivable area in this country which can not use fertilizer now would come in for the use of it——

Senator SMITH of Georgia. Because it is too expensive?

Mr. WASHBURN. Because it is too expensive; it does not give the farmer a sufficiently profitable return, and right at the edge—almost the center of gravity—of where 60 per cent of the fertilizers now consumed in the United States are used, namely, in the cotton States.

The burden upon the Government, so far as the fertilizer industry is concerned, would be nothing. The benefit to the farmer would be the absolute maximum, because the price at which the fertilizer will be sold to the farmer will bear a relation to the cost of production, and the cost of production at that point, for the reasons I have given you, would be an absolute minimum.

Senator SMITH of South Carolina. Now, Mr. Washburn, what other water-power site is available for the two interests? What other water powers do you know of in this country that would be available—not combining, perhaps, in the same degree the excellencies you have set forth.

Mr. WASHBURN. There is one other, in the Northwest on the Columbia River, what is known as Priest Rapids. Phosphate rock can be had there from the western deposits at a low transportation rate. Limestone is available at low cost of transportation, because it comes down the river, and while it is some distance away it can be very cheaply barged to the point of manufacture of the nitrogen. And there is the possibility—entirely feasible, too—of transporting the product to tidewater by barges, and then putting it onto the ships and bringing it around to where most of our fertilizer is used, which is on the Atlantic coast.

Senator SMITH of Georgia. That might not be available in time of war.

Mr. WASHBURN. Of course, there would be nitric acid produced there. It would be a very long way from the place where use would be made of it.

Senator SMITH of South Carolina. Are there any water-power sites where they have facilities for getting these other ingredients in different parts of the country?

Mr. WASHBURN. I do not know of any.

Senator SMITH of Georgia. Those are the only two powers that you know of——

Senator SMITH of South Carolina. You said this morning that 30,000 horsepower could be economically used in the production of atmospheric nitrogen, and I thought perhaps there were other powers.

Mr. WASHBURN. There are no smaller powers that could be used.

Senator NORRIS. I understood you to say this morning you did not know of any.

Mr. WASHBURN. No; I do not know of any powers, large or small, that I actually would feel warranted in developing for the purpose of producing nitrogen within the limits of the United States. I know of two large powers where, with the cooperation of the Government, it is practicable to do something in the production of nitrogen that has great economic significance to the country and would be profitable to the manufacturer.

Senator NORRIS. Take the Muscle Shoals proposition. The way you outlined it you divided up between the Government and private capital. I wish you would take two other views of it. First, suppose the Government does it all, manufacturing for the purpose of producing ammunition or whatever it may be needed for, either in time of peace or in time of war, and selling the surplus as fertilizer. Then take the other view of it. Suppose private capital should do it all and sell to the Government what it needed in the way of ammunition and sold the balance to the trade in the form of fertilizer or otherwise.

Senator SMITH of Georgia. Will you allow me to interrupt just a moment about the Government contribution? As I caught your idea, it was really that the Government would be called to contribute its credit, that if the Government contributed $20,000,000 private capital could afford to pay 3 per cent on the $20,000,000.

Mr. WASHBURN. Private capital would pay 3 per cent of such portion of the $20,000,000 as was involved in the furnishing of power to private capital, and that is $13,000,000.

That $20,000,000 is divided in this way, Senator Smith: $13,000,000 for the dam which serves navigation and also serves water power, power house, substructure, superstructure, and equipment of electrical machinery. That is all that is involved in the power. The locks at that point are estimated by the engineers at $1,875,000; we call it $2,000,000.

Senator SMITH of Georgia. Those locks are for navigation?

Mr. WASHBURN. They are for navigation purely and have no other use. There is no reason why the fertilizer situation should be burdened with an interest charge on navigation locks and their upkeep. Now, the amount of nitric acid required in times of war is so many times the amount of nitric acid that could possibly be used

or disposed of from that plant in time of peace that when you come to the last step, in which you produce nitric acid instead of a fertilizer, you have got to have some special machinery.

Senator SMITH of Georgia. That would be used for that purpose only?

Mr. WASHBURN. For that purpose only.

Senator SMITH of Georgia. But it ought to be there as a safeguard?

Mr. WASHBURN. It ought to be there as a safeguard. In fact, such special machinery as would be used in the making of nitric acid by the private interest and disposed of in the markets would be paid for by the manufacturer.

Senator SMITH of Georgia. Entirely?

Mr. WASHBURN. Entirely. So what does it amount to? It amounts to the Government furnishing power at 3 per cent of the cost of the power, and supplying $5,000,000 for a nitric-acid plant—or a part of it, the last step in the nitric-acid process—as a safeguard in time of war.

Senator SMITH of South Carolina. I would like to ask this question right here. Can the cost of the ingredients pure and simple be reduced by the operation of these factories as against the cost of nitrate of soda?

Mr. WASHBURN. Yes, sir; very much lower.

The CHAIRMAN. Is it your idea, Mr. Washburn, that in any adequate scheme of preparedness the Government must provide and maintain an establishment for the production of this nitrogen?

Mr. WASHBURN. It must provide a small portion of it—$5,000,000 out of about $44,000,000. That is the total required.

Senator SMITH of Georgia. He did not catch your question. The question was this: Is it your idea that in any complete system of preparedness by this Government for national defense we must be ready to make our own nitrogen inside the United States, where an enemy can not interfere with it?

Mr. WASHBURN. Absolutely.

The CHAIRMAN. And that the Government must either construct or assist in the construction of the plant?

Mr. WASHBURN. Absolutely.

Senator NORRIS. Returning to the question I asked, Mr. Washburn, would it be a practical proposition for the Government, taking Muscle Shoals as an illustration, to do it all?

Mr. WASHBURN. From the standpoint of human attainment; yes.

Senator NORRIS. But financially; take the Government's financial interest.

Mr. WASHBURN. Yes. Let us look at that for a moment. By the Government's going into the business of manufacturing and selling fertilizer and having part of the plant, the last end of it, available for producing nitric acid in time of war, by the investment of $44,000,000 it could go ahead and engage in the manufacture and sale of fertilizer and be safeguarded in time of war.

Senator WADSWORTH. Could it manufacture fertilizer profitably without capitalization?

Mr. WASHBURN. Yes.

Senator NORRIS. It would have the same capitalization that the private plant would have?

Mr. WASHBURN. Just the same.

Senator PAGE. Did I understand you to say it would not be practicable to utilize power that costs more than $10 a horsepower.

Mr. WASHBURN. I would like to take up that point. We spoke of the installation, dams, water wheels, and electrical machinery necessary to enable water to develop useful energy, very much as it is with a steam plant. We have a steam plant out here on the edge of Washington. Say it has a capacity for developing 30,000 horsepower. It costs $1,000,000. You ask the engineer what it is costing to make power, and he sums up the coal bill, the labor bill, depreciation, and interest on the investment, and says it is costing so much per continuous horsepower for a year.

Now, in hydroelectric development of energy the working cost of that energy is ordinarily about 80 per cent in the interest charge and only about 20 per cent in out-of-pocket expense. The cost of ordinary hydroelectric power development—and I know pretty well, because I have been connected with large power developments—as I say, is about 80 per cent in the interest account, because the interest and amortization cost is about 10 per cent in the development of water power.

The CHAIRMAN. How is that?

Mr. WASHBURN. The interest and sinking fund or amortization charge is about 10 per cent; in other words, if we have a plant that has cost, say, $2,000,000 cash we will find that interest and amortization on that plant is about $200,000 a year. Now, for private-capital developments in Canada we will say for such a water power as we have available there at $40—the interest and amortization charge would be 10 per cent of $40, which is $4 a horsepower. The out-of-pocket expense would be from $1 to $2. We will take the limit; if it is $2 more, that is $6 per horsepower year that the horsepower would cost us.

Now, if the Government developed a water power in the United States which does not cost as little as $40 but costs as much as $100 and we put an interest and amortization charge against the $100 of 4 per cent there is $4 for the interest and amortization charge on a plant costing two and a half times as much as the Canadian plant. And if we add $1.50 or $2 to that we get to $6. In other words, with the money furnished by that agency which has unlimited credit you can bring into the United States all of the advantages, so far as the burden upon the article produced is concerned, that you would have in going to Canada where your investment for power would be only 40 per cent as much.

Senator PAGE. Why would not this be the fair way to treat it: If that power in Alabama could be produced for $25 a horsepower, why would you say it was worth only $10 a horsepower?

Mr. WASHBURN. It is not the question, is it, of what it is worth? We have been dealing with the question of what it costs. Now, let us look at that question of worth. To begin with, one could not sell a large quantity of power in Alabama at that point for $25; but suppose we could. What use is made of it? It goes into a municipality for electric lights, street railways, and small motors. Do you know that the difference in Alabama between the cost of generating power by steam and by water is only a fraction of a cent,

and yet the city user of that power when it is distributed to him pays ordinarily about 6 cents. Now, what economic significance is there in saving a fraction of a cent in the cost of a horsepower to a customer who pays 6 cents for it. The feeling that the economic value of the development of water power is fairly related to the money value that it has for muncipal or general public use is a completely mistaken one.

Let us take a water power that is cheaply produced and used by a manufacturer as compared with municipal use. I figured it out during my connection with the Alabama Power Co., as president—one of the great power companies of the country—furnishing a great amount of power in central Alabama——

The CHAIRMAN. Is that water power?

Mr. WASHBURN. That is water power. Whether it is water power or steam power, so far as concerns the man who uses electric light, if he got all the advantage of the water power as compared with the steam, I estimated it would make a difference of 4 or 5 per cent in his monthly bill.

When you take that same water power and introduce it in an industry which cheapens your food supply, or produces, we will say, electric steel, which in turn has other uses—a large number of men are given employment—it puts an industry into that country that never would have gone there except for the cheap power. You have created something entirely new out of nothing. The project goes on, and results in its refinement in the employment of more men, introducing another industry. So that in the one place you have produced an absolutely new and valuable economic situation, which does not apply in any respect, as I see it, in the use of power for what we may call municipal purposes.

The CHAIRMAN. Do you mean that the consumer of power in a municipality does not get the benefit of the cheaper production of the water power?

Mr. WASHBURN. Ordinarily he does not get it; but even if he does it does not mean anything that is of political or economic importance.

The CHAIRMAN. He can not pass it on?

Mr. WASHBURN. He can not pass it on.

Senator NORRIS. If he does not get the benefit of it, it would be so small it would be negligible?

Mr. WASHBURN. It would be negligible.

Senator NORRIS. I want to ask you, in connection with the Government operation of power, about the development of the water power you were speaking of in Norway, and particularly in Germany. Is that done by the Government or by private individuals there?

Mr. WASHBURN. In Norway entirely by private individuals.

Senator NORRIS. And as to Germany?

Mr. WASHBURN. In Germany by private individuals until the war broke out.

Senator NORRIS. Now, was this 300,000 horsepower that you told us this morning had been developed since the beginning of the war developed entirely by the Government?

Mr. WASHBURN. That is by the cyanamid company under an arrangement with the Government, by which the Government con-

stituted a nitrogen monopoly, by which the sale of nitrogen in Germany until 1922 shall be first from cyanamid and, when that shall be exhausted, then of other materials.

Senator NORRIS. Do they make fertilizer?

Mr. WASHBURN. Oh, yes.

Senator NORRIS. Is this 300,000 horsepower——

Mr. WASHBURN. At the present time this 300,000 horsepower is producing explosive material, but at the close of the war it will turn to fertilizer.

Senator NORRIS. Now, what will be the expense at the close of the war in the way of machinery, etc., to change the output into fertilizer?

Mr. WASHBURN. Oh, it is a very slight change; it is not material.

Senator NORRIS. That is a point I wanted to hear you on. If these plants that you have been speaking about—I judge from what you say if you are going to manufacture fertilizer you would have some different machinery from what you would have if you were going to manufacture explosives?

Mr. WASHBURN. In the matter of nitric acid, we use a succession of processes, each with its own type of machinery. There are three main processes which stop at fertilizer nitrogen. Then, there is a small addition which converts the fertilizer nitrogen into nitric acid.

Senator NORRIS. As I understand you, in the Muscle Shoals proposition the expenditure on that last transformation would be about $5,000,000?

Mr. WASHBURN. For the Government's part of it, about $5,000 000. Private capital would manufacture nitric acid in this plant to the extent of 30,000 tons a year. That would leave 150,000 tons capacity in this final process to be installed by the Government. Of that 150,000, 90,000 would be absolutely complete, ready to start at a moment's notice, and the remaining 60,000——

Senator NORRIS. Would be used continuously?

Mr. WASHBURN. No. The remaining 60,000 at this point would have its buildings installed and everything stored except mercantile articles that are required, thereby requiring practically only labor to complete the plant to 180,000 tons capacity in three months. There would be no economy or sense in the Government's bringing it up the full 150,000 tons in the beginning, because it would take three months to get the initial Government plant fully in tune, as we call it, operating on a scale of 60,000 tons.

Senator NORRIS. When that was done and you proceeded there to manufacture explosives—180,000 tons, was it? They could not make any fertilizer at all when they did that, could they?

Mr. WASHBURN. Not when they were producing that full quantity.

Senator NORRIS. As I understand it, then, in the manufacture of nitrogen for explosive purposes you need additional machinery and put the product through one process in addition to what is required when you are manufacturing fertilizer only?

Mr. WASHBURN. That is entirely correct.

Senator NORRIS. And that additional machinery that you speak of would, in this particular case, to a great extent just be idle when you were making fertilizer and not explosives?

Mr. WASHBURN. Yes.

Senator SMITH of Georgia. The Government would need some nitrogen to prepare explosives, even in times of peace. Would it be feasible to continue the operation of a plant for fertilizer purposes and at the same time from such a plant make such nitrogen as the Government would need for the preparation of explosives during times of peace?

Mr. WASHBURN. Entirely so; and provision was made for that. Provsion is made for that with private capital, for the reason that it is anticipated that in the purchase of its nitric acid in times of peace the Government would pay the cost and a reasonable profit to be fixed at the will of the Secretary of War.

Senator KENYON. How do you mean that it has been provided for? Has this matter been arranged somewhere?

Mr. WASHBURN. In the plan that we have under discussion, which is the result of four months of study and an enormous amount of figuring and calculation——

Senator KENYON. Is it in this bill?

Mr. WASHBURN. No; it is not in any bill. It is the result of an invitation to me to confer with the War Department to consider means by which it may have a powder supply in time of war.

Senator KENYON. Do you understand, Mr. Washburn, that this bill before us now that we are trying to consider has any reference to the Muscle Shoals proposition? Is it applicable in any way to the Muscle Shoals proposition?

Mr. WASHBURN. I know of nothing in the bill except in a most general way that it proposes to appropriate $15,000,000 for the establishment of a Government nitrogen plant. I do not know that it has reference to Muscle Shoals or to any other particular place.

Senator KENYON. Do you understand that the $15,000,000 was to be used in connection with private capital at Muscle Shoals?

Mr. WASHBURN. Of that I know nothing.

Senator SMITH of Georgia. You knew nothing about the introduction of this bill yourself?

Mr. WASHBURN. Nothing whatever.

Senator SMITH of Georgia. You were not consulted by Senator Smith of South Carolina?

Mr. WASHBURN. No, sir.

Senator KENYON. You have had this matter up with the House Committee on Military Affairs?

Mr. WASHBURN. Yes, sir; I had a hearing before the House Committee on Military Affairs, and a hearing before the Agricultural Committee of the House.

Senator KENYON. Provision has been made in the House military bill, has it not, in section 82, covering this same thing?

Mr. WASHBURN. Yes; a general provision is there, authorizing the establishment of a nitrogen industry and the appropriation of such an amount as may be necessary to that end. It is very general.

Senator KENYON. But that is applicable only to the Muscle Shoals proposition, is it not, as contained in the House military bill?

Mr. WASHBURN. I should not think so; absolutely not. It is in the most general terms.

Senator SMITH of South Carolina. I should like to state, as the author of this bill——

Senator KENYON. I would like to have three minutes, at least, in which to ask questions.

Mr. WASHBURN. I understood that the hearing had no reference to the Muscle Shoals bill at all.

Senator SMITH of South Carolina. I want to say that in introducing this bill my attention had never been specifically called to the Muscle Shoals or any other water power in this country. The thing I was trying to do was to have the Government supply itself with this ingredient that is so necessary in both the capacities discussed here.

Senator KENYON. As I understand this proposition, there are only two places in the country where it can be done—Muscle Shoals and out in Washington.

Senator SMITH of South Carolina. I would like to have Dr. Norton, who is our Government man and who is thoroughly familiar with all these propositions, to appear before the committee, and I would like to ask permission of the committee to have him here and let him state just what he thinks about the situation.

Senator KENYON. I was just trying to find out about the bill.

Senator GRONNA. You stated that you knew nothing about this bill. Would it not be possible, without some legislation, to put into operation the plants which we have been talking about?

Mr. WASHBURN. We consider it commercially impracticable to establish a nitrogen industry within the limits of the United States. The proof of that lies in our plans and purposes.

The CHAIRMAN. Why could it not be done at Niagara Falls, on this side, as well as on the Canadian side?

Mr. WASHBURN. What we pay at Niagara Falls for our power now is more than we can afford to pay in continuing the industry, and what we can afford to pay is one-third to one-half of what we would have to pay for power on this side. We pay $10.50 per horsepower continuous on the Canadian side, which we could not get for less than $16, or, possibly, not less than $20 on this side.

Mr. BANKHEAD. Is there very much power on this side?

Mr. WASHBURN. As a matter of fact, there is a shortage.

The CHAIRMAN. Is there not sufficient power at Keokuk?

Mr. WASHBURN. That is an expensive power, and I do not know what remains there available as continuous power. We have to have continuous power every day of the year.

The CHAIRMAN. You do not know anything about the raw materials there, whether they will be available or not?

Mr. WASHBURN. We might get limestone, which is very important to us, but as to the question of a suitable coke supply, and, particularly, phosphate rock supply, it would be an unfavorable site.

I want to state to Senator Norris that the machinery for the production of the ammonium-phosphate fertilizer would be additional to the machinery and equipment for the production of nitrogen only; but if we are to produce the nitrogen material only which would be available for agricultural purposes as well as explosives, the ammonium-phosphate machinery would not be necessary.

Senator NORRIS. You could produce that at one place and ship it where you had the other material, and use it there?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. The question of transportation for the nitrate proper would not be a very large item, would it, Mr. Washburn? For instance, if we were going to manufacture nitrate now where there were not the other ingredients in that vicinity to mix it with and make fertilizer, would it be a practicable proposition to transport the nitrate to some other locality where the product did abound and mix it there and complete the fertilizer?

Mr. WASHBURN. Yes; such a thing is not illogical. Whether they have the actual, physical conditions to make it practicable at the moment, I can not say; but this will clear up what is probably a question in your mind: The first step, and, up to the present time, you might say, the only step in the production of a fertilizer nitrogenous material known as calcium cyanamid is to bring together the electric current, atmospheric nitrogen through the making of liquid air, limestone, and coal. You naturally want to be where the resultant of advantage as to those four things is the greatest. They produce a material which is a dark-gray powder. That material you can transport anywhere you choose, put it into what we call autoclaves, great boilers of inch and a quarter steel, transform it into ammonia, and from ammonia into ammonium nitrate, nitric acid, etc.

Senator NORRIS. The point I wanted to get, or rather the point I wanted to make plain, was that if we would manufacture nitrate in some locality where there were not the other materials necessary to make a balanced fertilizer, would the transportation of this nitrate be any considerable item? It would not be bulky or heavy as compared to the fertilizer, would it?

Mr. WASHBURN. That is just what we are doing to-day. We are transporting it from Canada long distances.

Senator NORRIS. You say you have to have limestone and coal?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. In other words, the things you make it out of would be air—and that we have everywhere—limestone, coal, and then the power to make it?

Mr. WASHBURN. Yes, sir.

Senator SMITH of Georgia. Water power?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. If you had the coal and the limestone located in the vicinity of the power, you would have a practical proposition?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. You could handle the balance by transportation?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. This product that is important for an explosive, the nitrate, does it deteriorate with age? Could it be stored and kept?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. It would be just as good years after it was made?

Mr. WASHBURN. Yes; so far as the quality of the product is concerned. It stands almost unlimited storage.

Senator NORRIS. The Government could, if it wanted to, prepare itself for war in time of peace, manufacture the nitrate and store it?

Mr. WASHBURN. When it comes to transforming that stored product into nitric acid, we have a very serious loss of efficiency with age. When it comes to using it as a fertilizer there is no loss. So it is not practicable to store it and hold it for the making of nitric acid.

Senator NORRIS. Could you not make it into nitric acid itself and store that?

Mr. WASHBURN. There is no way known of storing nitric acid except in aluminum vessels, or by mixing it with practically an equal quantity of sulphuric acid, and that is extraordinarily expensive, involving millions of dollars.

Senator NORRIS. It reduces itself to this, that it could be stored for the purpose of making fertilizer, but it would not be practicable to store it for the purpose of making explosives?

Mr. WASHBURN. Yes, sir; that is so.

Senator SMITH of Georgia. You mean, the original substance, the material out of which the nitric acid is made, can be stored?

Mr. WASHBURN. It can not be stored and used afterwards for nitric acid; it can be stored and used afterwards for fertilizers.

Senator SMITH of Georgia. I understand that you need two water powers sufficiently large and sufficiently well adapted, one in Washington and one in northern Alabama, near the Tennessee line?

Mr. WASHBURN. Those two sites are favorable ones.

Senator SMITH of Georgia. Your suggestion with regard to this one to which you have referred, the Muscle Shoals, is about this, is it not, that it would take a $44,000,000 investment to build the dam, to put the lock in the river, costing two millions, to put up a plant for the material that the Government would need for explosives, of five millions, and twenty-four millions for the additional plant and working capital for the fertilizer?

Mr. WASHBURN. Yes, sir.

Senator SMITH of Georgia. Your suggestion is that private capital could probably be enlisted in such an enterprise with the Government, furnishing its own $24,000,000 for the fertilizer end and paying 3 or 4 per cent interest on the $13,000,000 that the Government would spend for the dam, leaving the locks an expense to the Government as a contribution to navigation, and leaving the $5,000,000 plant that is exclusively for nitrogen——

Mr. WASHBURN. Exclusively for nitric acid.

Senator SMITH of Georgia. For explosives, to the Government?

Mr. WASHBURN. Yes, sir. I have mentioned 3 per cent, and I think that is the very limit, and not 3 or 4.

Senator SMITH of Georgia. You said 3 per cent?

Mr. WASHBURN. Yes, sir.

Senator SMITH of Georgia. Suppose the Government needed to obtain from that plant continuously, each year, that part of the nitrogen which it would use for its constantly made explosives. Could that nitrogen be obtained in that way from the Government cheaper than by buying saltpeter from Chile?

Mr. WASHBURN. Very much. I can give you the exact figures, if you want them; but I think that answers your question.

Senator SMITH of Georgia. Would it be sufficiently cheaper to carry the interest on the 5,000,000 out of that? That, of course, would depend upon the quantity used.

Mr. WASHBURN. If the Government uses what I believe myself it probably will use each year in times of peace in the future, there will be a saving to the Government of $700,000 to $1,000,000 a year on its nitric acid.

Senator SMITH of Georgia. Then that would carry the interest, a handsome rate of interest on the entire 7,000,000, or 2,000,000 for the lock and 5,000,000 for the additional plant?

Mr. WASHBURN. In times of war, compared with the present market on nitric acid and the cost at that plant, the Government would save in one year about $25,000,000. There is a fact that I think it is well to emphasize.

Senator SMITH of Georgia. So your estimate is that the Government could aid in contributing such plant and be out nothing except the temporary loan of the money, if we treated it as a loan. You would get 3 per cent on the 13,000,000 and have more than a return on the 7,000,000?

Mr. WASHBURN. Yes, sir.

Senator SMITH of South Carolina. Fifteen million pounds, or 7,500 tons, of nitric acid is consumed by the Navy Department annually. That is in the Navy Department. The consumption of nitric acid by the War Department is reckoned as from 1,500 to 2,000 tons per annum in the present estimate. However, provisions have been made for the purchase of six or seven thousand tons. For the past two years the War Department has been buying Chilean nitrate in advance of its present needs, anticipating a scarcity in the market incident to the European war.

The CHAIRMAN. Is there no way that the Government can get at the production of what it needs of nitric acid without all this expenditure of $13,000,000 on locks and dams and one thing and another?

Mr. WASHBURN. I do not know of any. I have been unable to evolve any plan whatsoever, and no informed person that I have ever heard discuss it has been able to.

The CHAIRMAN. Eliminating all this fertilizer production from this plan, what would the Government have to invest to provide itself with a sufficient amount?

Mr. WASHBURN. I think our estimate shows that simply for nitric acid alone about $30,000,000.

Mr. BANKHEAD. For the company?

Mr. WASHBURN. No; that is for the Government; and if the Government should simply provide itself with nitric acid plants to produce 180,000 tons and let it stand idle it would be about $30,000,000.

The CHAIRMAN. Is there no site where water power could be produced and followed by the production of this nitric acid in the United States at a much less investment than that?

Mr. WASHBURN. No; I do not know of any. I have had engineers out and I have done a good deal of investigating myself for five years. Our own consulting engineers that we had employed and myself have gone all around, and we know of only two places that are commercially available in the United States, even under the plans that have been suggested here, and no place that is commercially available in the United States compared to the advantages we would have in going to Canada.

Senator KENYON. Do you know whether the United States has made any investigation or not?

Mr. WASHBURN. The Government of the United States has a good deal of information, but all that is open to the public, and the information of the Government is general information, which induces the man who is going to make specific use of it to carry the investigation

further, so that our investigation is right down to the final analysis—what we call in chemistry quantitative.

Mr. BANKHEAD. You are manufacturing nitrogen in Canada?

Mr. WASHBURN. Yes, sir.

Mr. BANKHEAD. Where do you find a market for it?

Mr. WASHBURN. In the United States.

Mr. BANKHEAD. All of it?

Mr. WASHBURN. Practically all of it.

Mr. BANKHEAD. You ship it to fertilizer manufacturers?

Mr. WASHBURN. Yes, sir.

Mr. BANKHEAD. A great deal of it goes south?

Mr. WASHBURN. A great deal of it.

Senator KENYON. You have a company, have you not, ready to take up this work if the Government goes into this plan?

Mr. WASHBURN. Yes; I am confident of that.

Senator KENYON. Have you got a company now, and are you not a member of it?

Mr. WASHBURN. Oh, yes; we have a company that could carry out this enterprise just in the form that has been presented.

Senator KENYON. That company is what?

Mr. WASHBURN. The American Cyanamid Co.

Senator KENYON. Is that in Canada?

Mr. WASHBURN. Its works are in Canada, but it is a company incorporated under the laws of the State of Maine.

Senator KENYON. You have presented this proposition to Congress, have you not, several times as a power-plant proposition—this cooperation of the Government and a power company?

Mr. WASHBURN. No; I have never——

Senator KENYON. As to Muscle Shoals?

Mr. WASHBURN. No. I have never presented any proposition to the Government; I have made only suggestions, and I have never presented any kind of a proposition. I never made any suggestions that confined the matter to any particular site.

Senator KENYON. The appropriation has been in the river and harbor bill, has it not, and there was a separate bill on the floor of the House at the last session?

Mr. WASHBURN. That may be so; it is something I do not know about. My recollection of the water-power matter is this, if it is of interest to you: I have been largely interested in water powers for a number of years and the development of water powers, and the interests with which I was connected have suffered the disadvantage of not being able to develop water power, because they could not get the requisite Government permission, so I have felt that there ought to be some general legislation on the water-power situation.

Senator KENYON. You have been here helping with the Shields bill?

Mr. WASHBURN. I have helped with the Shields bill.

Senator KENYON. How long have you been in Washington working on these propositions?

Mr. WASHBURN. I think I have certainly, for the last six months, not been in Washington any time except upon the invitation of a committee or one of the departments in connection with anything of the kind.

Senator KENYON. Have other people associated with your company been working on the Shields bill or on this proposition?

Mr. WASHBURN. Yes; in connection with the Shields bill.

Senator KENYON. And on this proposition, too?

Mr. WASHBURN. Yes.

Senator KENYON. Mr. Worthington?

Mr. WASHBURN. Mr. Worthington has worked in connection with the proposed development at Muscle Shoals, primarily, as it originally was in the interest of the Muscle Shoals Hydro-Electric Power Co., which owns certain rights, etc., at Muscle Shoals.

Senator KENYON. What rights do they own there?

Mr. WASHBURN. Oh, they own possibly all of the abutment sites at the various dam sites.

Senator KENYON. Are you interested in that company, too?

Mr. WASHBURN. Yes; I have a stock interest in the company. Beyond that I am not connected with it.

Senator KENYON. What do you call that company?

Mr. WASHBURN. That is the Alabama Power Co.

Senator KENYON. You are also in the Muscle Shoals Hydro-Electric Power Co., are you not?

Mr. WASHBURN. No, sir; I am not connected with that.

Senator KENYON. One of the directors?

Mr. WASHBURN. I was until lately, but I have resigned from the directorate of the Muscle Shoals Co.

Senator KENYON. Are you chairman of the board of directors of the Alabama Power Co.?

Mr. WASHBURN. I was until a short time ago, when I resigned from it.

Senator KENYON. How many of these other companies are you connected with? The Alabama Traction, Light & Power Co.?

Mr. WASHBURN. That is the parent company of the Alabama Power Co.

Senator KENYON. You are a director in that?

Mr. WASHBURN. I am not now; I have resigned.

Senator KENYON. You have no connection with the Alabama Power Co. or the Alabama Traction, Light & Power Co. or the Muscle Shoals Co. When did you resign from those companies?

Mr. WASHBURN. Very lately, within a fortnight.

Senator KENYON. Since this matter has been brought up in Congress?

Mr. WASHBURN. Since this matter has been brought up in Congress; yes.

Senator KENYON. Did you say you were connected with the Muscle Shoals Hydroelectric Power Co.?

Mr. WASHBURN. I am not now.

Senator KENYON. You resigned from that, too?

Mr. WASHBURN. I resigned from that, too.

Senator KENYON. The Alabama Interstate Power Co.?

Mr. WASHBURN. No; I am not connected with that.

Senator KENYON. You were a member of the board of directors of that a short time ago, were you not?

Mr. WASHBURN. Yes, sir; it is a subsidiary company, and it may be that I have not resigned from it. I do not know.

Senator KENYON. You are connected with so many of them that you can not tell which you have resigned from. The Birmingham, Montgomery & Gulf Power Co.; are you one of the officers in that company?

Mr. WASHBURN. I do not know; my secretary can answer these questions better than I can.

Senator KENYON. Do you not remember being in this power company?

Mr. WASHBURN. I am not connected with either of those companies at present, my secretary informs me.

Senator KENYON. When did you resign from the Birmingham, Montgomery & Gulf Power Co.?

Mr. WASHBURN. That I can not say. It is one of the subsidiaries, and has no significance in this connection any more than the Alabama Power Co. or the Alabama Traction, Light & Power Co.

Senator KENYON. The Little River Power Co.; have you resigned from that?

Mr. WASHBURN. Was I ever a director of it? If you know, I do not.

Senator KENYON. The American Cities Co.?

Mr. WASHBURN. No, sir. I was a director of the company that controlled the American Cities Co.; that is, the United Gas & Electric Co., but I resigned from it.

Senator KENYON. They control the electric lines pretty generally down in that part of the country, do they not?

Mr. WASHBURN. You mean the Alabama Power Co.?

Senator KENYON. Yes.

Mr. WASHBURN. The Alabama Power Co. is the only hydroelectric company of any size in the State of Alabama.

Senator KENYON. Is that the company that desires to make this arrangement with the Government for this plant?

Mr. WASHBURN. No, sir; it has nothing to do with it.

Senator KENYON. You feel that this is a proposition that the Government is vitally interested in because of the danger of war, and it is a part of this preparedness that the Government should cooperate with private capital down there in the development of this plant?

Mr. WASHBURN. It is the only means that I know of, without visiting a great burden upon the United States, of insuring to it a powder supply in case of war, and the only means, whether it is a matter of burden or not, that will so provide a powder supply.

Senator KENYON. But this will be very valuable for the hydroelectric development, will it not?

Mr. WASHBURN. You mean, for some companies, the water-power companies?

Senator KENYON. Yes, sir; this cooperation between the Government and the corporation?

Mr. WASHBURN. So far as I know it has no relation to it at all.

Senaton KENYON. No relation at all?

Mr. WASHBURN. Absolutely none; I do not know of any possible connection between the two. This is a matter just as distinct as if I were interested in the manufacture of shoes in one place and the manufacture of salt in another.

Senator KENYON. Are you interested in the manufacture of fertilizer, too, in the country?

Mr. WASHBURN. No.

Senator KENYON. No connection at all?

Mr. WASHBURN. No.

Senator KENYON. Any connection with Mr. Duke in any of the fertilizer operations?

Mr. WASHBURN. Mr. Duke and his associates are erecting a plant for the manufacture of ammonium phosphate, and we have a contract with that company for supplying them with cyanamid, which will be converted into ammonium phosphate.

Senator KENYON. Are you interested in any of those companies of Mr. Duke's?

Mr. WASHBURN. No, sir; I have no interest in them, but I am very hopeful that we may enlist Mr. Duke and his associates in the development of this industry if we do it on a large scale. He would be a most valuable asset, and that is my hope. Mr. Duke has no stock in our company. I have no stock in any of his companies. He is not an officer or director in any of our companies, nor am I an officer or director in any of his companies.

Senator KENYON. Your real interest in the matter is the development of the water power, is it not, the hydroelectric power?

Mr. WASHBURN. No. There has been a great misunderstanding with regard to this whole relation of water power to the nitrogen industry. The nitrogen industry is separate. So far as power is concerned it is simply that it is used in the making of nitrogen just as other things are used; we use water power and limestone and coke and liquid air. Power is only one of the factors; that is all. It is one that we use a good deal of and is very expensive, and we must have it cheap; and anything that I am interested in or have been asked to interest myself in, in connection with the nitrogen industry, has no relation at all to any water-power company, nor has any water-power company any interest in it.

Senator SMITH of Georgia. You mean, water powers that are engaged in some other product?

Mr. WASHBURN. Any water-power company engaged in any other project or anything at all.

Senator SMITH of Georgia. Interested in the water power for its use or in any other way?

Mr. WASHBURN. It is not a water-power company.

Senator KENYON. What company is it, if it is not a water-power company that is interested in it?

Mr. WASHBURN. Interested in the matter that is under discussion here?

Senator KENYON. Yes, sir.

Mr. WASHBURN. The American Cyanamid Co., pure and simple.

As you have asked the questions, I think it might be illuminating to you to tell you just how my various connections have grown up, if you would like to know. I went South along about 1900 because I believed that the South was on the verge of a great economic development. I was a little early. I closed up my various companies in the North; my father, who was associated with me, retired from business, which gave me free capital, and we closed up

all of our undertakings in the North. I became interested in phosphate and coal mining and, among other things, in water-power situations in the South. I tried to develop those and tried to interest in their development American capital, which I was unable to do. A few associates who joined me in the matter and I were the owners of various water-power sites. We finally interested English capital to do the thing that we could not enlist American capital to do. It was very natural when English capital came in to develop the water powers and invest, as it did, in the State of Alabama about $10,000,000 of new money, that I should establish a relationship with these power projects during their period of development. I was accustomed to large organizations and the handling of men, and during the period of construction and the taking on of business and getting the company well fixed on its way as a purely operating concern, I was president of the Alabama Power Co. One of the things that during my earliest knowledge of Alabama most challenged my interest and my imagination was the Muscle Shoals situation. I worked on that project with Mr. Worthington, I think, ever since December, 1906, and I also, beginning in 1907, as I have told you, became attracted to the idea of the fixation of air nitrogen, growing out of my early experience in South America in the production of Chilean nitrates and the knowledge of the waning supply of the high-grade deposits, its increasing cost, and various other limitations connected with it.

I have had at no time any general ownership interest in any of the Alabama power companies, but a very minor ownership interest, almost inconsiderable, less than in almost anything that I am connected with; and lately there has been no reason for any further interest in or connection with the power companies, so that my entire interest in anything that touches water power is the desire to have water power for the development of the air-nitrogen industry.

Senator SMITH of South Carolina. I want to make a statement right here in connection with this——

Senator GRONNA. May I ask just one question before you make that statement?

Suppose the so-called Shields bill is enacted into law, and that independent capital will have an opportunity of getting power. Would it be necessary for the Government of the United States to appropriate any money in order to have this product manufactured? Would not private capital interest itself in the business without the Government going into the business?

Mr. WASHBURN. It will not, in my judgment, and I do not believe there is any way by which large private users under the Shields bill or under any other water-power bill can get water power in the United States for their use.

Senator GRONNA. May I ask you another question? I understood you to say that the Government of the United States would save $25,000,000 by going into this business of manufacturing nitrates which it must use or which it must have for its use for the Army; and I also understood you to say that the farmers of the United States are using $175,000,000 worth of fertilizer. It seems to me that with such a large amount as that being used, private capital ought to be willing to go into the business without Government aid. That

is, that is business enough to make profit without getting capital from the Government, is there not?

Mr. WASHBURN. The answer to that, as I see it, and as we have worked it out, is that private capital will develop the nitrogen industry and the use of nitrogen in this country, but it must develop it under such conditions and at such places as the nitrogen can be produced at a minimum of cost; because no large amount of fixed capital thus invested is safe, except where it can produce in competition as cheaply as or cheaper than at any other place under any other conditions.

Senator GRONNA. In other words, there might be a loss as well as a profit in this undertaking?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. Do you think the Muscle Shoals proposition would be developed under the Shields bill, for instance, that the Senator is speaking about?

Mr. WASHBURN. No; I do not.

Senator WADSWORTH. Why not?

Mr. WASHBURN. Because the cost of development in the United States is too enormous for the amount of product that could be sold and used.

Senator NORRIS. What is the object, then, of these companies? I do not remember whether you said it was your company, but some company, at least, that owned all the places, the riparian rights along the Muscle Shoals. What are they holding that for if it is not for the purpose of development?

Mr. WASHBURN. The water-power company is holding that under the anticipation that the Government will join in the development of water power at the Muscle Shoals, because thereby it would aid navigation.

Senator NORRIS. How long have they owned the land there?

Mr. WASHBURN. Since about 1912.

Senator NORRIS. It is the theory of these people, I suppose, that the Government will make that stream navigable, and in order to do it they will have to have this land that they own for the purpose of constructing dams or for the purpose of overflowing, whatever the case may be, and they can sell to the Government?

Mr. WASHBURN. No; hardly that. The Muscle Shoals investigations by private interests and the investigations of the Muscle Shoals enterprise by various Government engineer boards reporting to various committees in Congress from time to time have proceeded upon a suggestion, if you can call it such, of the Muscle Shoals Hydro-Electric Power Co., which said to the Government, "Navigation structures are needed at Muscle Shoals to complete navigation facilities on the Tennessee River, and we present to you a financial plan under which you will build those navigation structures, and we eventually can pay you interest on those navigation structures."

Senator NORRIS. Do you know how much is invested, how much they have invested in these properties where you have dams?

Mr. WASHBURN. I do not know; it is not a great sum.

Senator NORRIS. If it is not done for the purpose of making money out of it, these people will dispose of this large interest, will they, to the Government, should their investigation indicate that the Government wants it?

Mr. WASHBURN. It was the anticipation of the water-power company that they would hold those abutment sites until such period as they made an arrangement with the Government, and then those abutment sites would be turned into the whole proposition, because if they did not hold them, even the Government itself possibly could not have found a way of carrying out the enterprise.

Senator NORRIS. If they did not hold them somebody else would hold them?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. The Government would have had to pay for it if they built a dam there?

Mr. WASHBURN. Yes, sir.

Senator NORRIS. I do not know why they would invest their money in this uncertainty unless they expected to make some money out of it.

Mr. WASHBURN. The water-power company did not expect to make money out of the land that it purchased. They expected to comply with the laws of the State of Alabama, which require of a water-power company or of anyone developing water power that before he shall do it he shall own the abutment sites. They made themselves legally competent to come before the Government and suggest to the Government that here was a site where a great deal of power could be developed, but its cost was so great that it could not be done with private capital, but if the Government should put the navigation structures there, private capital could carry it from that point on and pay interest to the Government on the cost of the navigation structures——

Senator NORRIS. They could have done that just as well if they had not invested their money.

Mr. WASHBURN. Oh, no.

Senator NORRIS. It seems to me that it would have been in a little better shape, because they would have had a little direct financial interest of their own in it. In other words, they have an interest in it themselves. They want to sell to the Government the land that they are holding there——

Mr. WASHBURN. I do not think so. I have never heard such a suggestion.

Senator NORRIS. How can the Government build a dam if it does not own the land on which it builds the dam?

Mr. WASHBURN. But the Government, under all circumstances, at any time, has the power of condemnation.

Senator NORRIS. Oh, yes; I understand that.

Mr. WASHBURN (continuing). And can condemn the land necessary, whether it be owned by a power company or an individual.

Senator NORRIS. That being true, I do not see the necessity, unless they wanted to make the money out of the Government, to invest the money to buy these sites and hold them.

Mr. WASHBURN. This was the necessity: Before they could come before the Government as a public-utility corporation, with the legal power of developing water power and engaging in the development of water power, they had to own the abutment sites.

Senator NORRIS. Under the laws of Alabama?

Mr. WASHBURN. Under the laws of Alabama. So it was purely a matter of making themselves legally competent to make a proposition to the Government.

Senator NORRIS. You are sure that the laws of Alabama provide that before a company can come to the Government with that kind of a proposition it would have to buy and purchase the abutment sites?

Senator SMITH of Georgia. The riparian rights. Is not that what you mean? That whoever did develop that water power had to have that abutting land?

Mr. WASHBURN. Absolutely.

Senator SMITH of Georgia. And these people saw the place where it would, they believed, be beneficial to the Government to build dams for navigation purposes?

Mr. WASHBURN. Yes, sir.

Senator SMITH of Georgia. They bought up the lands, desiring to be in a position, not to sell them to the Government, but when the Government built the dam for navigation purposes to be in a position to make an arrangement with the Government to us the power for power purposes?

Mr. WASHBURN. That is the whole story.

Senator NORRIS. The Government, when it wants a piece of land, does not, as a rule, make an arrangement with the owner of the land. He sells it to the Government, and the Government pays for it.

Senator SMITH of Georgia. But the Government, creating a dam, creates a capacity for water power, too, because if it does not go into the business of selling the water power it would be in a position to sell that power to some private company that would use it, and only that power company could use it that had the riparian rights.

Senator NORRIS. But the Government could not build a dam in this abutment property unless it paid for it. If they did not own it, they would have to pay for it.

Senator SMITH of Georgia. But these people would be glad to give the privilege to the Government of building the dam.

Senator NORRIS. If Alabama has that kind of a law it would be a curiosity, that no man can come to Congress and ask Congress to build a dam unless he owns the land on which the dam is going to be built——

Senator SMITH of Georgia. Oh, that is not it.

Senator KENYON. Mr. Washburn says it is.

Mr. WASHBURN. Yes.

Mr. SMITH of Georgia. Nobody would be in a position to say to the Government, "I will contribute toward the expense of building that dam for any navigation purposes if you let me have the water power," unless they had the riparian rights.

Senator SMITH of South Carolina. Before we go to answer the roll call I have this bill coming from the House, 12766, and section 82 reads thus:

> That to provide for the fixation of atmospheric nitrogen by the development of water power, or any other means necessary to supply an adequate supply of nitrogen, the appropriation of such sum or sums of money to construct the necessary plant for such purposes is hereby authorized.

Senator KENYON. These are the only two places, according to Mr. Washburn, that that could be constructed.

Senator SMITH of South Carolina. I want to make this further statement, that I have introduced this bill for bringing out and determining whether or not it is feasible for the Government to go

into this business itself for the purpose of developing this ingredient without any regard to any private individual or any water power, anywhere or any place. I have simply wanted to get the fact that this is feasible and can be enacted into law.

Senator SMITH of Georgia. What you are after is the question of making nitrogen by someone, the Government preferred, if the Government could do it all right.

The CHAIRMAN. What is the desire of the committee?

Senator KENYON. Let us have some more hearings. This is a very interesting subject.

Senator SMITH of South Carolina. I want to ask the privilege, if we find it feasible, to have Dr. Norton here before the committee.

Senator SMITH of Georgia. There is one question I want to ask you. Suppose this dam was built; would that provide navigation from there on down the river?

Mr. WASHBURN. With only a slight addition it would provide navigation from there on down the river.

Mr. Chairman, possibly I can understand some of the difficulties of the committee, and it might help to clear up the situation a little by stating to you one other form in which the development of air nitrogen in the United States appealed to us. Possibly the plan is what you might call politically unsound.

Private capital has two difficulties to meet in the establishment of this industry—the large amount of money that is required and the correspondingly heavy interest burden, which are peculiarly objectionable and difficult to an enterprise which to Americans and American capital is so new.

Let use see what the aspect would be of the Government guaranteeing the company's bonds. Suppose private capital did the whole thing with the exception of the $5,000,000 going into the Government nitric-acid plant, and $2,000,000 in the locks. Suppose private capital put in approximately $40,000,000 and issued bonds. and those bonds were guaranteed by the United States Government, and the Government took a mortgage upon the entire outfit. The meaning of that would be that the United States Government had lent its credit to the establishment of the nitrogen industry, and so long as the bond interest is paid the United States Government would be at no loss and would suffer no burden. If the bond interest were not paid, the United States Government would come into possession of the property, and in operating it then would be in just the same position that it would be in if it invested in the beginning initially with $40,000,000, and proceeded on its own account to do the business.

The aspect of the Government holding so close and seemingly favorable relationship to a private interest may be offensive in principle; possibly it is something that the Government could not afford to establish as a precedent; but I think it expresses very clearly what one may call the broad equities of the situation, and it would give the Government and the people of the country and the farming interests every single benefit that they would have if the Government did the thing by itself, and entirely without placing any burden upon the Government, and in the event of the thing not going through or being a success the Government would find itself where. under the plan of Government ownership, it would have started.

The CHAIRMAN. Is not this whole agitation about the Muscle Shoals project primarily and is not the paramount object of it water power, and is not navigation an incident? Is not that what they are trying to work this water-power plant on?

Mr. WASHBURN. No; in my judgment the navigation requirements of the Tennessee River to-day are not sufficient to bear the burden of the enormous cost of navigation structures at Muscle Shoals. At the present time navigation on the Tennessee River is extremely moderate, but it would be, if they had through navigation from the upper waters, much in excess of what they have at the present time. If the Government could get these navigation structures there at a very much reduced cost, there is some point of expenditure at which the additional facilities for navigation provided in that way would warrant the expenditure, but to warrant the expenditure of all those millions and not have any return at all from the use of power, personally, I think is wrong, and at this time it would be a great extravagance. I have never known anyone to project the idea that Muscle Shoals ought to be developed purely as a navigation proposition. The effort has always been to find some way in which in providing the necessary navigation structures the burden to the Government would be reduced to a point where it was warranted.

Senator NORRIS. I would like to ask you some questions about the manufacture of nitrates by your plant in Canada. I think you have given probably most of the figures. How much did you say you manufacture a year?

Mr. WASHBURN. We manufacture—our capacity there is 60,000 tons.

Senator NORRIS. How much water power do you use?

Mr. WASHBURN. Pretty close to 30,000. We are running now 27,000 horsepower continuously.

Senator NORRIS. How much have you invested there in the business?

Mr. WASHBURN. The physical plant has cost us about two and a half million dollars.

Senator NORRIS. It is in the shape of a corporation, is it? You have that much capital stock?

Mr. WASHBURN. Our capital stock is in excess of that, and we have expended great amounts in experimental work and organization of the company and one thing and another, so that our cash investment is close to three and a half million dollars—about $3,300,000.

Senator NORRIS. You buy your power from some other company?

Mr. WASHBURN. We buy our power from the Ontario Power Co., which is one of the large power corporations.

Senator NORRIS. That is a company which gets its power at Niagara Falls?

Mr. WASHBURN. It has its plant at the base of the Gorge cliff and generates its power and sells it.

Senator NORRIS. They get their right to operate from the Canadian Government?

Mr. WASHBURN. They do.

Senator NORRIS. They have to pay something to the Government for their rights, do they?

Mr. WASHBURN. I think there is a small tax.

Senator NORRIS. On the horsepower developed?

Mr. WASHBURN. It is immaterial. I do not know what the conditions are.

Senator NORRIS. They do not have any direct bearing on the water power. We have had a great deal of discussion about the payment of rates, and I wanted to know what they actually paid, if you know.

Mr. WASHBURN. I do not know.

Senator NORRIS. How long have you been operating there?

Mr. WASHBURN. We began commercial operations in 1910, in January.

Senator NORRIS. Before you went there were you looking up Muscle Shoals with a view of developing that, or the Coosa River?

Mr. WASHBURN. No, sir; not before we went there. We started with a small plant at Niagara Falls with a capacity of 10,000 tons. Its capacity now is 60,000. We believed it was desirable and feasible to increase our productive capacity, and we wanted to do that within the United States. We endeavored to do that by the use of power on the Coosa River, and to secure a permit from the Government to that end. The Alabama Power Co. was to secure the permission to build the power plant. They were unable to secure that permission.

Senator NORRIS. They could not get the permits that they thought were sufficient?

Mr. WASHBURN. They could not get any permits at all. At that time, as at present, the general dam act of 1910 was governing, and under that act if one wanted a permit he had to come to Congress and secure it through a special act. One bill did pass both the House and Senate and was vetoed by President Taft.

Senator NORRIS. I understood you to say that you did not think there was any place in the United States where there was a water power that was in a practicable position to go into this business. If the Coosa River had these possibilities, and was practicable, and the Shields bill was passed, would that be one place where it could be commercially valuable?

Mr. WASHBURN. No, sir; it would not.

Senator NORRIS. As a matter of fact, you were not driven over into Canada because of the inability to get a proper place here, were you?

Mr. WASHBURN. No, we were not. To provide the increased capacity that we desired we at that time were not driven into Canada because of the high cost of power in the United States, but because it was impracticable to get such legislation as would permit us to do it in the United States.

Senator NORRIS. Coosa River was there the same as it always was. Could you not do that——

Mr. WASHBURN. No, sir; because conditions have very much changed. At that time the power that would have been developed for our uses on the Coosa, the primary power, which I believed I could, after the establishment of it, dispose of—it was not a very large amount any way—at a figure which would return me as much as I was then paying for it, and that I could have the benefit of secondary power to a large amount——

Senator NORRIS. And you were going to use that to make nitric acid?

Mr. WASHBURN. And we would have that comparatively small development in the South along the Coosa; but since that time we have

made our provisions for Canadian power which will not cost us over $4 a year for power, and we could not get power from the Coosa, I should say, for less than $18.

Senator NORRIS. The point I want to call your attention to is that you say, in your judgment, there is no place in the United States where it would be a practical proposition to develop power and make fertilizer.

Mr. WASHBURN. Yes.

Senator NORRIS. Yet, you do say that that is what you were going to do.

Mr. WASHBURN. Under the conditions at that time. That was a feasible matter. These conditions no longer exist.

Senator NORRIS. If the Shields bill passes, will not the conditions be ripe there?

Mr. WASHBURN. No, sir; the Shields bill will not alter commercial conditions, and we could not safely place ourselves in the position where our power would cost us what it would cost on the Coosa for any considerable development; and we have not the inducement to do it, because power and investment conditions which I hoped at that time to transform into a comparatively cheap situation no longer exist. There were special conditions which at that time made it feasible for us to make a development on the Coosa. They no longer exist.

Senator KENYON. What was that time that you spoke of? Did you refer to the year?

Mr. WASHBURN. I think it was 1912.

Senator NORRIS. Nobody has developed the power; the power is there just the same, is it not?

Mr. WASHBURN. Yes, sir.

Senator KENYON. Did you not make an address on the subject in 1913 before the National Conservation Congress?

Mr. WASHBURN. Yes.

Senator KENYON. And you discussed the Coosa River proposition then, that Senator Norris is asking you about, in that address?

Mr. WASHBURN. Yes; I discussed the Coosa River situation, and all of the conditions which surrounded it.

Senator KENYON. You said, did you not, substantially, in your address, that the Alabama Power Co. proposed to erect a dam across the Coosa River in Alabama, where the power was to be generated for the manufacture of cyanamid, a contract having been made by the power company with the cyanamid interests, providing for the use of all companies capable of developing it at Lock 18, and also an additional amount to be generated on a neighboring project? Do you remember discussing that in your address?

Mr. WASHBURN. Yes, sir.

Senator KENYON. Could you tell us what the contract was between the power company and the cynamid interests?

Mr. WASHBURN. Yes, sir. That contract provided that we should pay for absolutely continuous power $18 a horsepower.

Senator KENYON. That plant and a dam were to be erected solely by private capital, without any aid from the United States, were they not?

Mr. WASHBURN. That is correct.

Senator KENYON. You set forth in the address that its purpose was to produce an agricultural fertilizer, did you not?

Mr. WASHBURN. I judge so; it is a fact, anyway.

Senator KENYON. It was a good address, all right. And nothing was asked at all from the United States in that plan, was there?

Mr. WASHBURN. Nothing.

Senator KENYON. Why is there not just as much reason for asking aid from the United States in the Coosa River plan as in the Muscle Shoals plan?

Mr. WASHBURN. Because the whole situation that applies to the conduct of the nitrogen business and the successful carrying out of a large industry has changed. At that time the capital that was to be supplied for this development was to come from the same people who were supporting the power enterprise, and it was the only way at that experimental stage of the nitrogen company in which it seemed possible to secure the capital. Therefore a price for power was considered which would leave us a small profit—a much smaller profit—upon a limited capacity; but that was like taking a small part of your production—say one-third of it or a quarter of it—and enjoying very little profit, or much less profit than you would ordinarily enjoy. But that did not affect the great problem of our future development, or of the two-thirds or remaining three-quarters of our business. There were special conditions there that we were under, and there were also special conditions under which I anticipated that I would be able to take that same power and dispose of it in a more favorable market and supply ourselves with secondary power, of which there would have been a considerable quantity, with both of those developments on the Coosa River.

Senator KENYON. But you think the Government could not erect its own plant now on the Coosa River?

Mr. WASHBURN. Yes; the Government could erect a plant on the Coosa River, but the Coosa River is expensive of development, and at any particular power site there is not a great deal to be had; and the primary power, which is the all-year-round power, on the Coosa is very low.

Senator KENYON. I asked you awhile ago about this question being up in Congress before—of the development of this water power on the Tennessee River by the Muscle Shoals Hydroelectric Power Co. I ask you now if you did not propose a plan yourself, or through you as president of that company, some years ago to Congress?

Mr. WASHBURN. That is quite right; and that is the plan that in the most general way I tried to describe earlier in this hearing.

Senator KENYON. That plan was examined by a board of engineers?

Mr. WASHBURN. Yes, sir; by more than one.

Senator KENYON. What ever came of that?

Mr. WASHBURN. It was favorably reported upon by the final board of review, and it has ended right there. That was a plan to accomplish the very thing that Senator Gore was asking about, namely, means for providing navigation structures at Muscle Shoals without burdening the United States Government beyond the point where those structures were valuable or worthy as navigation struc-

tures. The very proposition that you now refer to had that object in view.

Senator KENYON. Nothing was said about the development of nitrogen in that proposition?

Mr. WASHBURN. No.

Senator KENYON. This nitrogen proposition had never been thought of in connection with Muscle Shoals until the war question arose?

Mr. WASHBURN. Yes; it had been thought of. I have never personally thought it was feasible for private capital to develop or assist in the development of power at Muscle Shoals and then sell that power to a nitrogen industry. It has been discussed, but I have never seen our way clear to do that because it would cost us more to do that than it would to do something else.

Senator KENYON. Another proposition as to Muscle Shoals was submitted to Congress or to the board of engineers through Mr. J. W. Worthington, was it not? You are familiar with that, are you not?

Mr. WASHBURN. Mr. Worthington became president of the Muscle Shoals Hydro-Electric Power Co. and succeeded me, and these consultations and negotiations, if you can call them such, were continued under Mr. Worthington's guidance, accompanied by various statements to the board and some to Congress.

Senator KENYON. You were familiar with Mr. Worthington's movements in the matter, were you not?

Mr. WASHBURN. Yes; in a general way.

Senator KENYON. You and he were interested in many companies——

Mr. WASHBURN. No; we were interested in a single company which had various subsidiary companies—by the way, those companies regarding which you asked me a while ago, from which I resigned, their charters were all merged into the Alabama Power Co., of which the parent company is the Alabama Traction, Light & Power Co.

Senator KENYON. That proposal to the United States engineering board with relation to Muscle Shoals was on December 10, 1913, signed by Mr. Worthington as president. Were you familiar with that proposal?

Mr. WASHBURN. I do not identify it by date, but I presume I was, because I was familiar with practically all propositions that were made.

Senator KENYON. There was nothing said about a nitrogen proposition there, was there?

Mr. WASHBURN. I imagine not.

Senator KENYON. Is it not the truth that the Muscle Shoals proposition has been before Congress in rivers and harbors bills, also as an independent proposition, and has been defeated either two or three times, and that the project now, the project in which you are interested, is to take advantage of the nitrogen feature in order to get the development of Muscle Shoals for the hydroelectric power? Is not that the real thing that is being tried to be done?

Mr. WASHBURN. No.

Senator KENYON. Is there not a large lobby here in Washington at this time attempting to do that very thing?

Mr. WASHBURN. It has no such relationship, directly or indirectly, and I hope that you will continue your questions, and this committee generally, until that question is answered satisfactorily.

Senator KENYON. I hope we can.

Mr. WASHBURN. And the nitrogen end of it, in its relation to Muscle Shoals, grows out of just one thing, and nothing else, which is that Muscle Shoals is a favorable site for the production of air nitrogen.

Senator KENYON. Nitrogen was never included in any of these proposals that have been made to the Board of Engineers for the Government until after the defeat of the Muscle Shoals proposition and this war question arose, was it?

Mr. WASHBURN. I do not know that the Muscle Shoals proposition was ever defeated. I can not recall it ever got to a point beyond an attempt on the part of the Government representatives and of private capital to arrange some project by which private capital might have the opportunity of developing water power and the Government could get its navigation structures, and at a cost——

Senator KENYON. Did you——

Mr. WASHBURN. Just a moment. The proposition made by private capital at that point was to have the Government provide navigation structures without cost to the Government, eventually to return to the Government not only the interest, but eventually the total cost of those structures.

Senator KENYON. Did you or those you represent attempt to have an appropriation placed in the rivers and harbors bill in the House for the development of the Muscle Shoals proposition?

Mr. WASHBURN. No; I have no knowledge of anything of that kind and no relationship to it. I can not recall that I have heard a suspicion of it.

Senator KENYON. You were here during the debate and progress of the Shields bill, were you not?

Mr. WASHBURN. I have been here for a day or a few hours at various times, I think, but not after the Shields bill was put on the floor.

Senator KENYON. Mr. Worthington was here, was he not?

Mr. WASHBURN. Mr. Worthington has been here.

Senator KENYON. Was a fund raised down in the neighborhood of Muscle Shoals to maintain a lobby here for the Shields bill?

Mr. WASHBURN. No; if there was, I do not know of it. There is an association known as the Tennessee River Improvement Association that has, I should say, a very natural interest in the development of the Muscle Shoals water power, because the development of the Muscle Shoals water power means the development of the central South on a scale that industrially would equal anything of that kind in the United States. The people of that whole section, the whole State, and the South generally feel an interest in it.

Senator KENYON. Who else has been here during the pendency of the Shields bill and during the time this proposition was before the House Military Committee as to the nitrate proposition?

Mr. WASHBURN. That I can not answer.

The whole water-power interests in the United States are extremely insistent upon legislation by which the development of

water powers in this country may go forward, and I know various gentlemen who are interested in it and representatives of various interests, and as a rule they approve the Shields bill and are working for its adoption and its passage, but so far as I am concerned I have no interest in the Shields bill beyond the interest that during the time I was connected with water powers in having some kind of a bill by which water power could be developed in this country.

Senator KENYON. In order that it may appear logically in the record, I want to ask you this—I covered it in a general way before our adjournment:

You are now president of the American Cyanamid Co.: you are, or have been up to within recent days, a director of the Alabama Traction, Light & Power Co.: chairman of the board of directors of the Alabama Power Co.; vice president of the Muscle Shoals Hydroelectric Power Co.: vice president of Anniston Electric & Gas Co.; and a director of the Alabama Interstate Power Co., the Birmingham, Montgomery & Gulf Power Co., the Little River Power Co., and one other. That is correct, is it not?

Mr. WASHBURN. That is correct.

Senator KENYON. And these companies practically control all of the water power in the State of Alabama, do they not?

Mr. WASHBURN. Most of those companies are nonexistent.

Senator KENYON. Just the parent company exists; the children have been abandoned?

Mr. WASHBURN. The company in the State of Alabama is the Alabama Power Co. The Alabama Traction, Light & Power Co. (Ltd.) is a Canadian corporation.

Senator KENYON. Mr. James Mitchell, of New York, and Lawrence MacFarlane, Senator, were directors of the Cyanamid Co. with you, were they not?

Mr. WASHBURN. Mr. Mitchell is still a director. I think Mr. MacFarlane is not.

Senator KENYON. You are also a director of the United Gas & Electric Corporation, are you not?

Mr. WASHBURN. I was; I resigned recently.

Senator KENYON. They owned the lighting and railway properties at many places, including Birmingham, Ala., Houston, Tex., Nashville, Tenn., Little Rock, Ark., Memphis, Tenn., and New Orleans, La., do they not?

Mr. WASHBURN. They own the stock in the company which is largely interested or controls the Birmingham Co.

Senator KENYON. Are you associated with Mr. Duke in the Cyanamid Co.?

Mr. WASHBURN. No.

Senator KENYON. Or in the cyanamid manufacture anywhere in the United States?

Mr. WASHBURN. No; only to the extent that Mr. Duke has been interested in this question of the production of fertilizer and attempting to engage in it for some time, and has organized a company for the manufacture of ammonium phosphate and has made a contract with the Cyanamid Co. for the necessary cyanamid to that end.

Senator KENYON. And this company controls the Ammo-Phosphate Co., of New York, do they not?

Mr. WASHBURN. They have nothing to do with it.

Senator KENYON. And the Amalgamated Phosphate Co.?
Mr. WASHBURN. No.
Senator KENYON. And the Virginia Chemical Co.?
Mr. WASHBURN. Nothing to do with that.
Senator KENYON. Nothing to do with those companies?
Mr. WASHBURN. Nothing to do with those companies.
Senator KENYON. Do they have any of those patents?
Mr. WASHBURN. Yes—only one of those because the Ammo-Phos Corporation operates for the manufacture of their product under our ammo-phos patents, or will do so.
Senator KENYON. And those companies practically control the fertilizer and cottonseed oil business of the territory east of the Mississippi River, do they not?
Mr. WASHBURN. The Ammo-Phos controls nothing. It has not a plant, and has never done a dollar's worth of business, and is an ordinary manufacturing undertaking which proposes to manufacture a new fertilizing material of a very extraordinary value, and to that end they have made the purchase of a mine of phosphate rock in Florida. That is the Amalgamated Phosphate Co.; and associated with Mr. Duke, because of its original ownership of this phosphate mine, are certain of those connected with the Virginia-Carolina Chemical Co.
Senator KENYON. They also control water-power interests in North and South Carolina, do they not?
Mr. WASHBURN. Mr. Duke is largely interested in the development of power in the Carolinas.
Senator KENYON. Mr. Worthington, who you say has been here, is a director of the American Cyanamid Co., is he not?
Mr. WASHBURN. Yes.
Senator KENYON. And the vice president and director of the Alabama Power Co.?
Mr. WASHBURN. No.
Senator KENYON. Is he connected with it?
Mr. WASHBURN. No; not at all.
Senator KENYON. Is he president of the Muscle Shoals Hydro-Electric Power Co.?
Mr. WASHBURN. He is; yes.
Senator KENYON. And director of the Alabama Interstate Power Co.?
Mr. WASHBURN. That does not any longer exist; that is my recollection of it. I think that is one of the companies whose charters were abandoned.
Senator KENYON. Under the laws of what State is the Virginia-Carolina Chemical Co. organized; do you know? Have you anything to do with that company?
Mr. WASHBURN. No; nothing to do with it. I do not recall. If I ever knew, I do not remember.
Senator KENYON. You are connected with that company?
Mr. WASHBURN. No; I am not connected with it and know nothing of it.
Senator KENYON. Are you connected with the Southern Power Co. in any way?
Mr. WASHBURN. Not in any way at all.
Senator KENYON. I think that is all I want to ask.

The CHAIRMAN. Mr. Washburn, I will ask you one other question. How many companies have been engaged in the manufacture of commercial nitrogen for fertilizers?

Mr. WASHBURN. You mean in this country?

The CHAIRMAN. In the United States; yes.

Mr. WASHBURN. Only one; that is our own company, for the manufacture of the nitrogen product.

The CHAIRMAN. I thought you said Mr. Duke had a company.

Mr. WASHBURN. Mr. Duke has organized a company, which is to use our patents for the manufacture of ammonium phosphate. That is the only company that uses any of our patents outside of ourselves—well, I might say that the du Ponts used one of our patents in the manufacture of ammonia from cyanamid.

Senator SMITH of South Carolina. This ammonium phosphate is a process that you hold the patent on—the combination of those two?

Mr. WASHBURN. Yes.

Senator SMITH of Georgia. They just pay you a royalty for the use of your patents?

Mr. WASHBURN. Equivalent to that; they pay us a fixed sum.

Senator SMITH of Georgia. For the use of your patents?

Mr. WASHBURN. Yes.

Senator SMITH of Georgia. Just as anybody else would use your patents and pay you for the use of them?

Mr. WASHBURN. Yes, sir.

Senator WADSWORTH. Mr. Washburn, how long ago did you say you were in consultation with the Army engineers?

Mr. WASHBURN. Six months ago.

Senator WADSWORTH. You came upon their invitation?

Mr. WASHBURN. I came upon their invitation.

It would possibly be of some satisfaction to the committee, as well as tend to clear up something for me to say—it has not occurred to me to do so until now, but it is perfectly evident in everything we have considered here—that there was no purpose, no idea of using any part of this power which the Government should provide for the nitrogen industry for anything except the local use of it, and therefore, it follows inevitably that no water-power company would have any interest in——

Senator SMITH of Georgia. The nitrogen?

Mr. WASHBURN. The nitrogen, or if the Government wanted electric steel, for that is the method by which the armor steel is made, not only by the Krupps in Germany, but by the Creusot Works in France. The power, if any were available, could go into that purpose; but there is no part of the power that could go to a water-power company or be distributed. In fact, there is not any there to be spared. We want every bit there is, at Dam No. 2, in any event, if that should be the chosen site.

Senator KENYON. How long will it take to develop that power at Muscle Shoals?

Mr. WASHBURN. It will take, to complete and get the thing all in working order, about four years.

Senator KENYON. My idea was whether or not it would help us very much on this proposition if we got into war within four years?

Mr. WASHBURN. Yes; it would, for this reason: That it would be practicable to provide about half of the requirements in 18 months.

either by the use of an initial steam plant, which we could make use of afterwards as a stand-by during the low water period, when we should require more power, or by the purchase of power from the surrounding power companies, of which there would be three, which in the event of war could extend their lines and get to that point; so it is an 18 months proposition.

Senator NORRIS. You could not get anything quicker than 10 months? I ask that, because in one of the leading articles on preparedness, and one of the books that has been written, and which received an immense circulation and a great deal of newspaper comment, has us whipped by the 1st of April, 1916. So, unless you could develop your process there within the next 10 days it would not be of any value to save us.

Senator WADSWORTH. Mr. Washburn, have you talked over with the officers of the War Department this same proposition you talked over with us?

Mr. WASHBURN. Yes, sir.

Senator WADSWORTH. Is there any material difference in your proposal to them and what you have made here?

Mr. WASHBURN. I think there is none. We have considered a great many different plans, but they have all the same basic principle, and, since the original suggestion, which I was most attached to, that of having the Government guarantee the bonds and take a mortgage on the property, was early abandoned, since that time they have all turned upon the proposition of the Government furnishing power, as a power producer, and private capital furnishing the rest.

Senator WADSWORTH. Furnishing the factory?

Mr. WASHBURN. Furnishing the factory.

Senator NORRIS. With what Government officials did you consult?

Mr. WASHBURN. Chiefly with Gen. Crozier. I discussed the matter in the Agricultural Department, and, as you know, with two of the committees.

Senator WADSWORTH. With whom in the Agricultural Department?

Mr. WASHBURN. I had two interviews with Secretary Houston, and he brought to the first interview Dr. Whitney and three of his associates.

Senator WADSWORTH. Did you discuss the engineering problems with any of the Army engineers?

Mr. WASHBURN. In part.

Senator WADSWORTH. With the Chief of Ordnance?

Mr. WASHBURN. Yes.

Senator WADSWORTH. In part, you say?

Mr. WASHBURN. In part. The engineering features, so far as they apply to the development of power at Muscle Shoals, are thoroughly well known. I do not think that I ever discussed with the War Department any particular power site. We discussed the fact that Muscle Shoals and that of Priest Rapids, on the Columbia River, were available, but most of our discussion was turned upon the cost and the practicability of providing this nitric acid.

Senator WADSWORTH. Who besides yourself helped to make the estimates of this cost of the entire installation?

Mr. WASHBURN. No one, except our staff of engineers.

Senator WADSWORTH. Of your company?

Mr. WASHBURN. Of my company.

Senator WADSWORTH. Are you at liberty to say whether any of the officials of the Government with whom you have consulted approved of your proposal?

Mr. WASHBURN. I think I am at liberty to say anything I know. My impression is that they are favorably disposed toward it, and their expressions have been to that end, but nothing that would commit them to the proposition.

Senator WADSWORTH. That is, in both departments?

Mr. WASHBURN. That is true of the War Department. There has been no expression from the Agricultural Department.

The CHAIRMAN. Are there any other questions by any Senator? [After a pause.] If not, you may be excused.

Mr. WASHBURN. Mr. Chairman and gentlemen, I thank you.

The CHAIRMAN. We are very glad to have had you here, Mr. Washburn.

Is there anyone else who desires to be heard on this subject?

STATEMENT OF MR. MILLARD F. BOWEN, OF BUFFALO, N. Y.

The CHAIRMAN. State your name, place of residence, and business.

Mr. BOWEN. My name is Millard F. Bowen, and my residence Buffalo, N. Y.; by profession I am a lawyer. My work for several years has been in connection with the organization of the Erie & Ontario Sanitary Canal, which is a proposed company legally incorporated under the laws of the State of New York, to build a canal from Lake Erie to Lake Ontario, for a number of purposes, among others the generation of power. It is called the Sanitary Canal because it is copied after, in a measure, the Chicago Sanitary Canal, which turned the Chicago River backward. As a sanitary canal, we would drain into our canal all of the storm waters and sewers of Lackawanna and Buffalo, the two Tonawandas, and all the adjacent towns, Lockport, and even Niagara Falls.

The full drop between Lake Erie and Lake Ontario is 327 feet. My attention was called to this after an industrial proposition years ago by the fact that the Niagara Falls Power Co., the pioneer, uses only 136 feet of this 327 feet. By constructing this canal that would take care of all of the sewers, we can so construct it so as to utilize 313 of the 327 feet of fall, thereby getting an efficiency with every cubic foot of water that we would use of 2.3 times as much as the efficiency of the Niagara Falls Power Co., and that would enable us to get a larger income with the same amount of water.

We have asked the War Department for 6,000 cubic feet, which is the smallest amount of water used by any of the power companies in Niagara Falls; and with this 6,000 cubic feet we could generate 190,000 horsepower electrically, by using it over several times, having several power houses, by the same water passing through each one in succession.

The company is only in its promotion state, as far as capital is concerned, although we at first, before we began the engineering features of the company, made a contract for the necessary capital—$30,000,000—to be available at the time the permit of the Government would be granted for the use of the water.

In 1910 the treaty with Canada was promulgated, in which the contracting nations pledged themselves to stop the pollution of the international waters, and the clause which, in article 4, relates to that states [reading]:

It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other.

Article 5 of the same treaty provides, first, that Canada shall have the use of 36,000 cubic feet of water per second for power purposes, whereas the United States is given for power purposes only 20,000 cubic feet. That is by reason of the fact that the greater volume of water flows on the Canadian side of the river; but for other purposes there is a further amount over the 20,000 that is available, because the last clause of article 5 says [reading]:

The prohibitions of this article shall not apply to the diversion of water for sanitary or domestic purposes, or for the service of canals for the purposes of navigation.

This canal, being for sanitary purposes, and also for navigation, as far as what is called the "escarpment" at Lockport, not for ships, but for barges, it comes under both provisions of that clause of article 5. Furthermore, the treaty seems to have been drawn largely in view of the various uses that this water could be put to.

In article 8 it says [reading]:

The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:

(1) Uses for domestic and sanitary purposes.

(2) Uses for navigation, including the service of canals for the purposes of navigation.

(3) Uses for power and for irrigation purposes.

The foregoing provisions shall not apply to or disturb any existing uses of boundary waters on either side of the boundary.

So there is a complete case made out in the treaty providing that a reasonable amount for sanitation and navigation can be granted for these other purposes, and 6,000 cubic feet is, according to the scientists, a reasonable amount for such purposes.

So this matter was brought up several years ago, first, under Mr. Alexander, in the Rivers and Harbors Committee, and when the following Congress came in it was transferred to the Foreign Affairs Committee of the House, and is there still, and it is a long-drawn-out matter to get it settled. There does not seem to be any reason why it should not be settled. There would surely result from the development of these plans not only the use for pure water for 600,000 people, but the Government also would receive the use of free harbors, one at each end of the canal, and there are periodical yearly floods in that neighborhood, and this would stop all of the floods.

The CHAIRMAN. How long would this canal be?

Mr. BOWEN. Forty-two miles from lake to lake. And then the barge canal terminals and lake-level maintenance, all of these, from an engineering point of view, are vouched for by one of the greatest engineers in the country, who has often been called in for consultation by the Government, Mr. Isham Randolph, of Chicago, who is our chief consulting engineer, and his reports are available.

Senator NORRIS. About what size would the canal be, the excavation?

Mr. BOWEN. It starts in only 18 feet deep by 60 feet in width, at one entrance. There are two entrances, one at Lackawanna—perhaps you can follow the little map there [indicating in pamphlet], and the other entrance through the present Erie Canal, which has a larger cross section; and at the lower end it would be 24 feet deep, because you notice [indicating] there are two branches there, and they meet and form a larger volume at the lower end, toward Lake Ontario, but it would be large enough.

Senator NORRIS. The one branch would run around the east side of Buffalo?

Mr. BOWEN. Yes.

Senator NORRIS. And the other would start on the west side of Buffalo?

Mr. BOWEN. Yes; so as to make the drainage and stoppage of pollution complete.

Senator NORRIS. How far would it be from the Canadian line?

Mr. BOWEN. The creek down which it goes from Lockport to Olcott is called "Eighteen-Mile Creek," because it is 18 miles from the Niagara River. So, the power houses would all be on that creek, 18 miles away from the boundary line.

Senator NORRIS. It would not be used for anything except power purposes?

Mr. BOWEN. And the drainage—yes, the right of way will give us, we expect, an income from other purposes, that is, industrial purposes. Our company is organized with the idea of carrying on manufacturing and warehousing.

Senator NORRIS. How many dams would there be?

Mr. BOWEN. There will only be two dams, but the principal power house, having the greatest fall, will be fed through penstocks, not a dam, the penstocks running from what is called the "escarpment," which is the same as the Niagara Falls itself, at Lockport.

The proposition that it has appeared to me might be feasible in this connection to interest the Government, aside from this public work that would be done, is that we would have 190,000 horsepower. We would not ask the Government for any money for the development. We could very readily, as Mr. Washburn has explained, since it takes 30,000 horsepower for 600,000 tons of cyanamid or nitric acid—I do not know just exactly how he terms that——

Senator GRONNA. I think he said 60,000.

The CHAIRMAN. Sixty thousand is his annual output.

Mr. BOWEN. Three times that would be 180,000, which is the total amount which he says the Government would need in war times. For 60,000 it takes 27,000 horsepower, and three times that would be 81,000 horsepower, which would be less than half of the total amount of our development.

Now, it would be, I think, reasonable to place in our contract for the sale of power, and further use of the power in our own factories, a clause that in time of need by the Government that that amount should be available for the Government.

Mr. Washburn has said also that it takes for the development of 60,000 tons, $2,500,000, and three times that would be $7,500,000.

If that should be the total cost for a plant to give the full capacity for Government use it would represent the full investment that the Government would have in any event to put into it, because we would then only charge the Government regular rates for the power when they used it.

That is entirely new to me, but it has come out in the testimony to-day. I have never thought of such a proposition, except that I have talked with Dr. Norton about this whole proposition, and you will notice that Dr. Norton is one of my indorsers and speaks about it very highly. There is his letter there [indicating pamphlet], and I think he will vouch for all the details of this plan, and not only will he, but you will notice——

Senator SMITH of Georgia. What will be the cost of digging the canal?

Mr. BOWEN. The full cost of the digging and the equipment will be within $30,000,000. The present capital of the canal, for the initial promotion expense, is simply $100,000, part of which has been issued, partly for cash and partly for services, and none of the stock of the company has been put upon the market or sold for any purpose except for enough cash to keep the expenses going, and the expenses even—it is rather remarkable that such a proposition has been so good that all of the engineering expenses have been paid, the engineers themselves cheerfully taking our stock on the probability of this being put through as a paying concern, and therefore it has been the most economical promotion probably that has ever been put through; but in regard to the application for the permit, there is a stumbling block.

Senator SMITH of Georgia. You do not own the rights of way?

Mr. BOWEN. We do not need to buy anything. It is all farm land. Until we get our permit and issue our bonds—we do not issue any bonds or securities until we get the permit.

The stumbling block is simply this: Under this treaty the President asked the Attorney General what his powers were. The Attorney General made a written opinion, in which he said that the President has the power under this, which is the supreme law of the land, to carry out its provisions, irrespective of any act of Congress. But, under that opinion of the Attorney General given to the President, when I asked the Secretary of War whether he would act under that opinion, he said as long as the matter had been placed before a committee of Congress that he would not feel justified in proceeding until Congress disposed of the matter.

At the last session of Congress a year ago, Congress reported this, what is called the Cline bill, from the Foreign Affairs Committee for passage, but in the rush of the adjournment clean-up it was lost, and the same bill has been introduced and is now before the Foreign Affairs Committee, and they are simply wating now before reporting it again, because they have been requested by the Niagara Falls Co. to come to the frontier and examine for themselves all of these conditions surrounding the permits before they report a bill.

The existing power companies have no rights except as tenants by sufferance. The Niagara Falls Power Co. has always had 8,600 cubic feet, and the Schoellkopf Co. 6,500 cubic feet. I understand from some source that that 8,600 cubic feet has been increased temporarily,

at least, without any written permit, to 10,000 cubic feet, to take care of the peak load, as it is called, for the Niagara Falls Power Co., so that they are probably using 10,000 cubic feet now, and that would be 10,000 cubic feet for the Schoellkpof Co., if the Government sees fit to grant it, and still leave under the other clause of the treaty provision to make this 190,000 horsepower from the 6,000 feet; and, as I say, at the rate of development of efficiency, 2.3 times as great as the efficiency generated by the Niagara Falls Power Co.

I have also had to appear under these provisions of the treaty, before the International Joint Commission, and they have not made a report in regard to their recommendations. The matter was referred to them by both Governments for their recommendations, not for any order, but simply that their engineers should examine into the subject and stop the pollution of international waters, and make such recommendations as their engineers should see fit to make in regard to the topic of pollution: but they have no power. In fact, irrespective of the International Joint Commission, the treaty gives the rights to the officers of this Government to make this grant, irrespective of the other articles of the treaty. Article 5 gives this country the absolute right to make this grant and the other two grants for the companies at Niagara Falls.

On the Canadian side of the Falls there is a greater development than on our side: but it seems that on their side they will soon be stopping their power in Canada, and not allow the export of power to this country, as it is now being exported, showing all the more need why this development should proceed.

Dr. Norton the other day, in talking about the time that this would take in the matter of development, thought that by the use of the most modern powerful machinery we should be able to do it in a year. "Oh," I said, "Dr. Norton, no; it is utterly impossible to do such a great work in a year; but working night and day, three shifts, with the most powerful machinery, might do it in 18 months."

Senator SMITH of Georgia. It would take you a good while to get your rights of way to start with. You would have to litigate for a large number of them. You would have to get the power of condemnation.

Mr. BOWEN. We have got that power already.

Senator SMITH of Georgia. In your charter?

Mr. BOWEN. Yes; we have.

Senator SMITH of Georgia. You would have to litigate all of them.

Mr. BOWEN. I do not think so. We are a very reasonable and a very hopeful people.

Senator SMITH of Georgia. They would all be mighty reasonable.

Senator KENYON. The bonds might be given to them as the bonds are given to the engineers.

Mr. BOWEN. Some have offered to take our bonds in exchange for their property. They are so anxious to get a return. It is almost vacant and useless land as it is. Following the streams as it does, much of it overflows. From an engineering point of view it is a perfect development, and the streams that now flow into Lake Erie carry the wash water of the streams. All of this filth, from the

cities along the way, will be turned into this canal, and, then, we follow the gorge down below Lockport—that is a natural outlet.

Senator SMITH of South Carolina. Your idea, in coming before this committee in reference to this bill, is for the Government to cooperate in the development of that power?

Mr. BOWEN. Not in the development of the power, only in the use of it, except to this extent—that is, to build this nitrate plant, if you choose, upon our right of way.

Senator NORRIS. You mean that the company would develop the power and sell it to the Government?

Mr. BOWEN. Yes; as you need it.

Senator KENYON. Would not that be a dangerous location for one of these plants in case of war?

Mr. BOWEN. It is 18 miles away. Well, A. P. Townsend, who is interested at Niagara Falls—interested in the Hooker Electrolytic Co. and others—said that this was an ideal place, because not only is Niagara Falls a center for great chemical industries, but it was so far away from the Falls that the risk of the location of the chemical plants on the border would be done away with. That is an idea that I got in conversation with Mr. Townsend, who is thoroughly familiar with all of the conditions there.

I want to make this plainer, if there is any question regarding it. I have the reports of the engineers, and all of the details of the surveys, etc.

The CHAIRMAN. There has been no engineer of the Government that has made a survey, I suppose?

Mr. BOWEN. Oh, no; we have only called upon our own engineers—taking largely the Government surveys that have heretofore been made for various purposes.

The CHAIRMAN. Does any Senator desire to ask any further questions?

Senator GRONNA. Have you any idea at what rate the company could sell the power?

Mr. BOWEN. The average rate that we have estimated for our income and sinking fund and overhead charges and everything is an average of $20. That would enable us to make a better rate for part of it.

Senator WADSWORTH. Twenty dollars a horsepower?

Mr. BOWEN. Yes; for 24 hours' service.

Senator GRONNA. It is not the intention of your company, then, to build these nitrogen plants, but simply to sell the power; that is really your desire?

Mr. BOWEN. It is so new to me that that is the only thing I have thought of to-day while listening. I came here without any preconception at all, simply because I saw in the paper you were going to have a meeting on this subject, and I was interested to let you know that this is one of the squarest deals probably that has ever been put up to the Government in all of its details, and you will notice there in that pamphlet the names of such men as Maj. Gen. William C. Gorgas, Dr. Wiley, Mr. Nowell, and others who have been connected with the Government for years, who indorse it from its engineering and sanitary standpoints.

Senator GRONNA. But you are reasonably sure that 190,000 horsepower could be furnished?

Mr. BOWEN. Yes, sir.

I thank you for your consideration.

The CHAIRMAN. And we are very glad to have heard you.

STATEMENT OF MR. R. F. BOWER, REPRESENTING FARMERS' NATIONAL UNION AND NATIONAL GRANGE, CAMPBELL, VA.

Mr. BOWER. I would like to be heard, but I do believe this committee has had pretty nearly enough discussion of the nitrogen question this afternoon, and if it could be possible I would prefer much that we have a full meeting of the committee some other time and take up this question. I want to present it from the agricultural standpoint. You have heard from the scientists and the experts and the manufacturers, and we believe this is an agricultural committee, and you know very well that the farmers' organizations that I represent—the Farmers' National Union and the National Grange—have not enforced the preparedness proposition, and we want this nitrogen question considered like Senator Smith has considered it, from the agricultural standpoint, and the benefits that will result to American agriculture and to the farmers.

Senator GRONNA. As one of the members of the committee, I shall be very glad to be here and hear you.

Senator NORRIS. Have you in mind any particular power development?

Mr. BOWER. The farmers' organizations passed a resolution here in Washington—the National Grange board of directors and the board of directors of the Farmers' National Union in joint conference. It names no locality, it names no process; we are not interested in any locality or process, provided the locality and process is selected that will produce fertilizer in the most economical way of any considered.

Senator NORRIS. You favor the production of the fertilizer by the Government direct, do you?

Mr. BOWER. I would, Senator Norris, if I thought it was feasible and a practicable plan to do that, and that it would be worked out and Congress would adopt it.

I think that the opposition to Government ownership and the Government going into business of that kind, in addition to the opposition of establishing a nitrogen plant of any kind, would be so great that such a plan could not be developed.

Senator NORRIS. You believe in the Government going into partnership with the private parties?

Mr. BOWER. It depends upon what the restrictions upon the cooperators are. I think if the Government should make a cooperative enterprise of that kind undoubtedly a provision could be provided by the Government, at least, to see that the price should not be monopolistic.

Senator SMITH of South Carolina. But you would be in favor of the Government doing this alone if it can be done as proposed by this bill, without any cooperation or coordination or any other arrangement with anybody else except the Government?

Mr. BOWER. If the Government can do it and produce the fertilizer as cheaply as it can be produced under the cooperative plan,

I certainly would, and I think the farmers of the United States would absolutely indorse me in that.

The CHAIRMAN. What concrete plan have you in mind?

Mr. BOWER. We have no special concrete plan. We farmers are not hydroelectrical chemists or experts, nor are we engineers. Our proposition, as we thought it might best be figured out, would be to leave that to engineers and the experts.

Senator SMITH of Georgia. You want the Government to take an interest in producing cheaper nitrogen?

Mr. BOWER. That is one point we insist upon, if possible.

Senator SMITH of Georgia. You feel the nitrogen ought to be produced, and if it is such a big enterprise that private citizens won't go into it and develop it, you farmers ought to take hold?

Mr. BOWER. Absolutely. And in addition to that we fear, under the conditions of the nitrogen fixation processes, that we will just jump from the hands of the Chilean monopoly to the hands of another monopoly if the Government does not take some hand in this and furnish a plant and thereby get a controlling interest in the industry, or do it entirely.

There is no question about the supply of nitrogen. There is no question about the extent of the Chilean nitrate business. Other beds have been discovered farther inland, of course, and more expensive for development, but the world's supply is there for generations to come. The production of nitrogen is a question of economic interest to the farmer, and his ability to use it—that is the essence of the nitrogen question, the cost of it, not the supply of it to the farmers.

Senator GRONNA. Your chief interest is in the cost?

Mr. BOWER. Our chief interest is in the cost, absolutely.

Senator SMITH of Georgia. Of course, if we should be involved in a war and be cut off from Chile, that would be a different proposition.

Mr. BOWER. We are not anxious for war by any means, but we will leave that to gentlemen that have those things under consideration.

Senator SMITH of South Carolina. I came across this reference by Dr. Norton in a communication he sent me from the department, that they had made no improvement in the methods of gathering this Chilean nitrate or transporting it, for the reason they had no transportation.

Mr. BOWER. Absolutely; there is no question about that.

Senator NORRIS. There has been no incentive to improve the methods.

The CHAIRMAN. There is a big export duty, too.

Mr. BOWER. That is just the point I wanted to bring out.

(Thereupon, at 4.55 o'clock p. m., the committee adjourned, to meet Friday, March 17, 1916, at 10.30 o'clock a. m.)

WITHDRAWAL OF WATER-POWER SITES AND CONSTRUCTION OF WATER-POWER PLANTS FOR MANUFACTURE OF NITRATES.

FRIDAY, MARCH 17, 1916.

UNITED STATES SENATE.
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met at 10.50 o'clock a. m., pursuant to adjournment.

Present: Senators Gore (chairman), Smith of South Carolina, Smith of Georgia, Gronna, Kenyon, Wadsworth, and Johnson of South Dakota.

The CHAIRMAN. Gentlemen, at the time of adjournment yesterday we were listening to Mr. Bower.

Senator SMITH of South Carolina. Mr. Chairman, I have brought this morning Dr. Norton, who is so busy engaged in the department that I thought it would be best to hear him this morning, and I want to state that Dr. Norton is thoroughly familiar with all of the details of this, and I would be glad for him now to address the committee.

The CHAIRMAN. That will be agreeable to you, Mr. Bower?

Mr. BOWER. Yes, sir.

STATEMENT OF THOMAS H. NORTON, PH.D., SC.D., BUREAU OF FOREIGN AND DOMESTIC COMMERCE, WASHINGTON, D. C.

The CHAIRMAN. Doctor, we would be very glad to hear what you have to say in regard to the fixation of nitrogen or any related subjects.

Senator SMITH of South Carolina. Might I suggest to the doctor that the points we want to bring out and stress are, first, the available power in this country for this purpose; next, whether it is practicable; and, third, and most important of all, the question of the Government going into this water power simply and alone, without any complications with anybody else. We want to discuss those phases.

Dr. NORTON. Mr. Chairman, I will state in the beginning that I have been for four years intensely interested in this whole matter. Perhaps some of you are familiar with my publication on the "Utilization of Atmospheric Nitrogen."

When we come to study the sources of available power for this purpose we have practically two to consider: First, and most important, is the water power of the country. That is the chief source of power, now at least, for the utilization of atmospheric nitrogen

on the other side of the ocean, and also to the very limited extent in which the manufacture is now carried on in Canada, immediately across the border from Niagara Falls. The possession of cheap water power has hitherto been regarded as almost the only condition for creating this industry. We must, however, bear in mind, as you will find by referring to my report on the subject, in the closing chapter, that the necessary power can be generated at a very low expense by utilizing the enormous piles—the mountains, as we might term them—of waste coal in the immediate vicinity of our great coal mines, notably, in western Pennsylvania and in certain regions in the South. That is a source that has not yet been considered to the extent which it practically deserves.

But for the moment we need to consider only the available water powers, and you will find those practically falling into three geographical districts. We have in our southern Atlantic States, the southern part of the Appalachian Range, down along through North Carolina, touching South Carolina, Tennessee, and Georgia, a number of water powers, which in the aggregate command the attention of all interested in this question. The water powers available in Georgia, at Tallulah Falls, have now been entirely preempted, I understand. I was informed a few days ago by a hydraulic engineer who has investigated this whole subject in the southern Alleghenies that one interest controls, largely in North Carolina and Tennessee, a sum total of about 200,000 horsepower.

Senator KENYON. What is that interest, Doctor?

Dr. NORTON. That was stated to me as being practically under the personal control of Mr. James B. Duke.

Senator SMITH of South Carolina. Yes, sir.

Dr. NORTON. This I am simply mentioning as a statement made to me by a hydraulic engineer connected with the works in Georgia. I have not been able to verify it yet from personal investigation.

Then, we have in the northwest, and to some extent throughout the Rocky Mountain section, a fairly large amount of water power. I have had my attention called within the past 10 days to several of these sources. Gentlemen, who came across from the Pacific coast to consult with me, plan utilization of these powers more particularly for certain phases of chemical industry. Now, for example, I have in mind one water power in the immediate vicinity of Seattle. The late mayor of Tacoma came over to see me two weeks ago in regard to that. There is a water power of 15,000 horsepower not yet used for any purpose——

The CHAIRMAN. Excuse me a minute. I have to go to another committee meeting.

(Thereupon Senator Smith of South Carolina took the chair.)

Dr. NORTON (resuming). Which ought to be put to proper use.

Senator JOHNSON of South Dakota. May I ask what, in your opinion, is the minimum power that could be practically used for this work?

Dr. NORTON. You can start in with any amount. You can start with 5,000, 10,000, 15,000, 20,000, or 30,000 horsepower. Less than 10,000 horsepower is economically not very advantageous. The industry requires to be mounted upon a large scale in order to produce the highest economic results.

Senator SMITH of South Carolina. What, in your opinion, would be the lowest horsepower concentrated in a single plant?

Senator JOHNSON of South Dakota. That is what I want.

Dr. NORTON. I should, from my observation in Europe, especially in Scandinavia, say that we ought not to start any individual plant with less than 30,000 horsepower. I should put that as about the minimum figure.

Senator JOHNSON of South Dakota. How many places in the United States do you know of, Doctor, that could develop about that amount of horsepower?

Dr. NORTON. As I was just about to remark to you, another water power up in Washington was brought to my attention a few days ago of 60,000 horsepower, which is now owned or rather controlled by the Great Northern Railroad. I am not familiar with the exact conditions. They are utilizing only 1,000 or 2,000 horsepower, in order to hold it, but there is about 60,000 horsepower available at one point. There are other water powers scattered around in the Yellowstone region. We have quite an amount of water power available down in the Yosemite region.

Then, apart from the southern and southeastern development, and the northwestern, to which I have referred, certain developments have taken place in the Mississippi Valley—the Keokuk Dam is probably familiar to you. I think there is something like 200,000 horsepower there. But there are a number of such isolated points.

Finally, we come to our greatest national asset, which is on our frontier, that is at Niagara Falls. The sum total of the water power susceptible of utilization there resulting from the drop between the level of Lake Erie and the level of Lake Ontario is about seven and one-half million horsepower. That represents, I think, roughly about one-half of the total horsepower of the country.

Here comes into consideration an enormous water power of which one-half would naturally belong to Canada and one-half to us. By international arrangement we are allowed 20,000 feet per second and Canada is allowed to take 36,000, according to the treaty of May, 1910. That involves a total utilization of about 25 per cent of the available water supply of the Falls.

There have been very ingenious, sensible, and economical propositions brought up lately for diverting, under the existing treaty arrangements, a certain amount of that water, taken from the immediate neighborhood of the city of Buffalo and brought over by a very short canal to the city of Lockport, where I passed much time in early days, and am thoroughly familiar with the whole topography of the country. I have been interested in propositions for diverting, partly for sanitary use, and largely for economical uses, under existing treaty regulations, a fairly large amount of the water of Lake Erie at that point. That is eminently worthy of the consideration of your committee, as it would, as far as my knowledge goes, supply much more than is needed to start profitably and economically a very large plant.

Practically, gentlemen, I feel, from various standpoints, that the country should have, in a rough way, three such installations.

The largest amount of nitrogen in the combined form, required for agricultural purposes, is probably needed in our South Atlantic

and especially in our Gulf States. You will find in the cotton fields and in the tobacco fields of the South that there is relatively a greater need of nitrogen, and I might say in this connection of potash, than in any other section of the country. From the purely agricultural standpoint, there ought to be a center for the production of nitrates from the air at such a location that the agricultural needs of the South should be met with a minimum of expense, as far as transportation is concerned.

We have to consider, then, the needs of our Pacific coast, and there is, as I have mentioned, a large available amount of water power not yet utilized. That could supply the economic needs, the needs for the varied industries of the Pacific coast as they exist at present, and as they will be prospectively rapidly developed, and also its agricultural needs.

The consumption of nitric acid itself is growing very rapidly. There is probably no other article on the lists for freight rates, submitted to our Interstate Commerce Commission, which involves greater difficulty for the transporting agency and a higher rate than that of nitric acid. In Germany, for many years, the Government has not allowed nitric acid to be transported on a train which is used for other purposes. They use special trains for that purpose, such as are assigned for explosives.

In considering, therefore, the needs of the western half of our Nation for nitric acid, an important factor in manufacturing, there should be a center of production there which would be free from the handicap of high rates of transportation for haulage from one side of the continent to the other.

When you consider, however, the chief uses of nitric acid and of the nitrates, outside of use for fertilizers, they are centralized chiefly in our Northeast. The southern half of New England, a great share of New York State, a large portion of New Jersey, almost the whole of Pennsylvania, the territory reaching through Ohio toward Chicago and down to Baltimore in our adjoining State come into consideration. In this region nine-tenths of the nitric acid manufactured in the United States is consumed in the arts. Here are the chief centers for the production of the high explosives required in ordinary peaceful times for our quarrying, for our blasting, and for use in other purposes, such as building roads, etc. There is a large consumption of nitric acid in connection with the manufacture of dyestuffs and the multiplicity of various chemicals required in a host of different trades and industries.

If I were to sum up the demands of this country for the consumption of nitrogen in a combined form, especially in the form of nitric acid, for its industries, and notably for the manufacture of explosives, both for peaceful uses and for the defense of the Nation, for the normal provision of defense for the future, I would state that we ought to have three plants. One should be located in the South for the manufacture of nitrates—to a slight extent nitric acid. The use as fertilizer should be the dominating factor. In such a plant the whole equipment could inside of 24 hours be shifted off to the manufacture of nitric acid for use in the preparation of explosives, if our liberty was ever menaced. Normally it would manufacture nitrates for the use of the agricultural section constituting the Gulf and South Atlantic States.

Another plant in the Northwest could supply the needs of the western section of our country, nitrates for agriculture, nitric acid for its rapidly growing industries.

The largest plant should be located in the Northeast to meet nine-tenths of the domestic demand for nitric acid used in the arts, and to meet the needs of the largely diversified agriculture extending from the Mississippi to the Atlantic and north of what you might call Mason and Dixon's line in ordinary parlance. Ultimately we should have a center immediately in the Mississippi Valley. The manufacturing interests of this section are steadily developing. Their needs must be provided for in the future. Unfortunately we have no easy source of power now available in the center of that section. If we analyze it geographically, I would state that, with regard to the present consumption of nitric acid and the materials used in that connection, with regard to safety from possible interruption in time of war, such a location, geographically, leaving out of consideration the question of available water power, ought to be about Pittsburgh. If you go a little farther east, as far as Philadelphia or New Jersey, which geographically would be the center of consumption of nitric acid and of the nitrates, we are getting a little too near to the seaboard. I feel as if Pittsburgh was, from an industrial standpoint and from the geographical standpoint, the ideal location for the Northeast. We are, however, without available water power in the immediate neighborhood of Pittsburgh unless we consider the possibilities of the Parker plant, 50 miles to the northeast of that city.

In order to secure available water power, we must go from 150 to 200 miles to Niagara. Here arises the international question, whether the possibility of conflict with our neighbors to the north is of such a nature that it would preclude the establishment of a plant for the fixation of atmospheric nitrogen in the immediate propinquity of our northern border. Personally, I do not anticipate any danger from that source. I have lived 10 years of my life in Canada, and I do not think that danger will ever arise from that quarter. It is, however, a question that will have to be considered.

Senator Smith of Georgia. Is it not a scientific question, Doctor?

Dr. Norton. It is not a scientific question. It is purely of a strategic nature.

Senator Johnson of South Dakota. The location of those plants which you mention should largely be considered from the standpoint of transportation, also, should they not?

Dr. Norton. Yes, sir. I have felt that for the Northeast, the consumption of nitric acid and of the nitrates, both for industrial purposes and for agricultural purposes, would be centered somewhere around Philadelphia or New Jersey. That would take in the consumption in New England, the consumption reaching south to Maryland and Virginia, and reaching out westward to Ohio. We have no available water power in the immediate neighborhood of the Atlantic.

I think that, apart from scientific or technical questions, when we consider the production on the basis of its being a potential source of supply for national defense, the location should be 100 miles or 150 miles from the seaboard. I feel convinced that the dangers which would come to any such plant, would result largely from a rapid invasion, which might take place anywhere along our seaboard. Fortunately, in the southern part of the country the

water powers are some little way back from the seaboard, in the Appalachian range. I do not think there would be any danger for a prospective plant either in Tennessee, Georgia, Alabama, or North Carolina. I think that is far enough off to protect us from any sudden raid.

If we should have such a plant located in western Pennsylvania, say, which is a wonderfully convenient location, from the purely industrial standpoint, and the standpoint of distribution, it would not be a difficult thing to draw the power from Niagara. I have already alluded to a plan for creating a supply of power near Buffalo capable of execution at very slight expense. The current could be transported as easily to the neighborhood of Pittsburgh as we now transport electric current in California. It is transported there 130 miles with perfect ease. There is no technical difficulty now to transport it 200 or 300 miles. The current generated at Niagara is now used as far east as Syracuse. It is expected that within a few years the electric current generated at Niagara will be transported direct to the city of New York, to be used in the electrification of the subway and other methods of transportation. The distance in this case is double that between Niagara and Pittsburgh.

In case of invasion—we will suppose an invasion from the Canadian border—it will be a very easy thing to protect simply a transmitting line, and in case of sudden interruptions to reconstruct it in a few hours. The main plant would, however, be so far away from the international border that it would practically be safe.

I should state, therefore, that the leading plant, the central plant, with reference to the industrial evolution of the country, ought to be in western Pennsylvania.

Another plant, almost equal in extent, but aiming dominantly, entirely almost, to meet the agricultural needs of the South, ought to be located somewhere near the point where Georgia, North Carolina, and Tennessee meet. A third plant should be sufficiently removed from the Pacific littoral in our Northwest.

This is the way I have sized it up—a little roughly, perhaps. Geographically and from a strategic standpoint, I think that these are the lines along which we ought to carry out our studies.

Your chairman has brought up a third point, perhaps fundamentally the most important in this whole connection. It is, Should this Government embark in the manufacture on a large scale of nitrogenous products? Is it a branch of manufacture which could legitimately come within the purview of the United States Government? Should it not better be confined to private initiative?

We have within the past few years embarked in phases of activity at Panama, and now up in Alaska, which during the nineteenth century would have been utterly foreign to the ordinary ideas of the functions of the Government. If we face this nitrogen problem I can not recall any better arguments that could be brought in favor of organized industrial activity on the part of our Government than those arguments which were so forcibly and abundantly presented to the Senate and the House of Representatives a dozen years ago, when the question was agitated of building the Panama Canal. Almost every argument adduced at that time bears directly on this nitrogen question. The matter of national defense predominated, but ques-

tions of transportation and of the industrial independence of our country were forcibly presented.

At present we are largely dependent, along with the rest of the world, on a single source of nitrates in the South Pacific. We are paying tribute, in common with the rest of the world, to the extent of two-thirds of the running expenses of the Republic of Chile; that is, we are contributing our share of the total sum. Two-thirds of the running expenses of that country are defrayed out of the export duty on Chile saltpeter. In the event of war the same arguments which were brought up for the necessity of a canal through the Isthmus of Panama to connect our western coast with our eastern coast, to allow of easy transfer of a fleet from the Pacific to the Atlantic and vice versa, may be applied with equal force to this chief source of combined nitrogen for the agricultural and industrial needs of this country. I feel, therefore, that all the arguments, irrespective of political considerations, that were presented a few years ago in connection with the project for constructing the Panama Canal, would bear with equal emphasis and force on the question now under discussion by this committee.

Senator SMITH of Georgia. Doctor, in that connection, may I ask a question? You say it bears with "equal force." Suppose we were at war with a nation with a large fleet; does it not bear with greater force? How would we get along without nitrogen and continue to make powder and explosives?

Dr. NORTON. That is a fundamental question. Were we at war with a nation that had the naval command of the Pacific, dependent as we now are, our supply of nitrates would be cut off to the last pound.

If we were at war with a nation which had the naval command of the Atlantic, we could count on a possible supply, brought from Chile to San Francisco, and then shipped by rail, at considerable expense, across the country to the eastern centers.

Senator SMITH of Georgia. But what I wanted you to tell us is this: Suppose we were cut off from Chile. What could we do if we were cut off?

Dr. NORTON. A fortnight ago I published details on this point. Perhaps telepathically I had an idea that your committee might need the information. We would be in exactly the position in which Germany would be in to-day, if four years ago she had not developed methods of winning the nitrogen from the air, which enable her to supply the entire needs of her army when fighting for life and death, and also to partly meet the legitimate demands of agriculture. If five years ago Germany had entered upon the present war, she would probably have been forced ere this to sue for peace.

Senator WADSWORTH. Doctor, did the German Government four years ago go into the business of manufacturing combined nitrogen?

Dr. NORTON. The German Government did not at first go into the manufacture of combined nitrogen. It encouraged in every way, as I have outlined in a recent report on the subject, the development and the perfection of two or three simple processes, which were brought to such a stage 12 months before the war broke out, that Germany is now able to manufacture its high explosives without a pound of Chile saltpeter. I am credibly informed, by chemical friends in Germany, that the German authorities would have hesitated to have embarked in any military effort on an immense scale, when they would

run such a risk of seeing vitally essential supplies cut off, had it not been for this rapid evolution in the processes for the fixation of atmospheric nitrogen, which took place within the past three or four years.

Germany has next to no water power—a mere fraction of what we have in this country. The Germans can utilize, however, their waste coal, and they can utilize the few forms of water power at their command. But they have developed another process which has been tried in no other country, by which the nitrogen of the air is extracted directly, without dependence upon cheap water power. They have developed a method, described in the second chapter of my recent report [indicating pamphlet] by which nitrogen is changed into the form of ammonia. That ammonia, at very slight expense, and with great ease, can be oxidized, in contact with ordinary air, into nitric acid.

The CHAIRMAN. That is a very recent process, is it not?

Dr. NORTON. I was at Mannheim on the Rhine, three years ago, when the works were under construction. A friend had charge of the construction of this first factory for manufacturing ammonia from the nitrogen of the air. Simultaneously a method was developed by a leading chemist, Prof. Ostwald, for oxidizing this ammonia into nitric acid. Neither of these operations is based upon the use of water power. They have not been attempted in any other country, but they do put in the power of Germany, without the use of a single waterfall, the ability to make from the air which we breath every pound of explosives necessary to shell Verdun or any other point.

That could not have taken place four years ago.

The CHAIRMAN. Is that cheaper than the other process?

Dr. NORTON. There are, as I mentioned in this article which I published a few days ago, only three available processes so far as we know. The first is the manufacture of cyanamid, which is carried out on the Canadian side of Niagara Falls. It can be most advantageously carried out with water power.

Senator SMITH of South Carolina. What is the difference in the cost, where coal is used under present conditions and where water power is used?

Dr. NORTON. There you have an enormous range of expense. We can get waste coal now, which can be used very largely for this purpose, in the western part of Pennsylvania for 50 cents a ton. That depends entirely on the locality. On the Pacific coast a pretty high figure is quoted for coal, as you know.

When we come to the matter of water power, there are all the variations between $2 for an annual horsepower in Iceland and at a few points in Norway; $3 for the larger plants in Norway; $4 or $5 as you get into Sweden; $10 to $15 in the Alps of central Europe; and, finally, $20 at Niagara Falls. We find all of those variations. In New York City there is a rate of $80 for the electric current derived from coal. Electric current can be used for the direct tranformation of the air we breath into nitric acid; it can be used, however, advantageously only where the water power is so exceedingly cheap, as it is in Iceland, or as it is in the western half of Norway.

The problem has been worked out for Niagara Falls. Were we to harness the whole cataract on an entirely different basis from that hitherto devised, the cost per horsepower would come down to about

that prevalent in Norway. The cost of the installation would involve an annual interest charge of about $1.80 per horsepower. Then would come the cost of operation—the ordinary running of power houses, etc. That means the complete utilization of Niagara Falls, as outlined in the document in the hands of your chairman, for a certain portion of each day, at least.

The smaller water powers in our country require a greater expenditure of capital relatively in order to render them available. We must construct dams on a very large scale and reservoirs something like the Roosevelt Reservoir in our western country, in order to secure a supply of water during the rainy season, or during the spring, which could be available later in the year when there is but little precipitation.

Fortunately, at Niagara Falls we have a fairly uniform amount of water, draining the whole area of the lakes, available at all times of the year.

Senator Smith of South Carolina. In spite of the comparatively high cost of water power between this country and Europe, yet the production of nitrogen for military and agricultural purposes in this country would make the product cheaper, even at that, than what we have to pay for the Chilean saltpeter, would it not?

Dr. Norton. It certainly would, gentlemen, because we would secure the product from Niagara Falls. Practically all of the cyanamid now made on the Canadian side is brought across the line, and is used in American agriculture. The manufacture is based upon a standing cost of $20 per annual horsepower. The nitrogen derived from the air in that way easily meets in competition Chile saltpeter. It holds its own; the works are being enlarged. That demonstrates to us, with perfect clearness, that we can take the nitrogen out of the air; we can put it into such a form that it is susceptible of utilization for our agriculture, and on even terms with the supplies from Chile.

Furthermore, gentlemen, you must remember that the supplies of Chile saltpeter are limited. When I wrote this report, which is in your hands, it was thought that within a quarter of a century the supply might be exhausted at the present rate of exploitation. Further investigation, since my report came out, shows that probably that date can be very materially advanced. But it is a limited quantity. It is like a mine of copper or a lode of gold or silver in our West. It is topographically limited, and the day will come when there will not be one pound more available for use. We have got to face this proposition, not only for our current needs, for the needs of our Government, for the needs of national defense, but we have got to face the possibility of what will happen 20, 30, or 40 years hence for our agricultural interests and for our manufactures, if we do not have such an industry well established, moving along smoothly and easily, ready to engage and enlarge its scope of operations as the American demand increases. All that has to be taken into consideration.

Senator Johnson of South Dakota. Does this atmospheric process used in Germany combine the manufacture of high explosives with any other products?

Dr. Norton. No. First, I might say that the methods used in Scandinavia produce nitric acid directly, and that is changed into

nitrate of lime. In that form it is sent out for agricultural use. You can, however, prepare the nitric acid without changing it into nitrate of lime, which is much easier to ship. It can be concentrated, and can also be transformed into other forms of nitrates for different purposes—saltpeter, for instance, to be used in making gun powder. When recently in Norway, studying the nitrogen plants, I found that they were manufacturing nitrate of ammonia, which is now used to a very large extent in connection with high explosives.

The manufacture is exceedingly elastic. The main product is for use in agriculture. If there is a demand for nitrate of ammonia, for use in connection with explosives, in a few hours the production can be in full operation. If nitric acid itself is required, for use in manufacturing dynamite or guncotton, or for any other similar purpose, it is possible to switch the manufacture, at a day's notice, into those lines. It is exceedingly elastic.

The same statement applies also to cyanamid, although not in a similar degree. Cyanamid has the nitrogen in the form of ammonia. It is ready for agricultural purposes as manufactured. If it is desired to manufacture nitric acid, in order to make use of it for high explosives, the cyanamid is treated with steam. Ammonia is liberated, and is transformed into nitric acid by the method developed within the past two or three years in Germany. That means a certain complication, as compared with the direct transformation of the medium in which we live into a corrosive article like nitric acid.

Senator SMITH of South Carolina. Is this method of transforming it from the atmosphere called the "arc" process, as distinguished from the cyanamid process?

Dr. NORTON. Yes. The operation is carried on in the electric arc at a temperature of over 3,000° C. The cyanamid method can be carried on at a temperature of 1,100° C.

Senator SMITH of South Carolina. What is the difference in the cost of producing nitrogen by the two processes?

Dr. NORTON. There is not much difference. The advantage of the cyanamid process is that you work at a lower temperature—that is, as far as concerns its use for agriculture. But in the arc process you get your nitric acid direct for use in the arts and for use in making explosives. With cyanamid it is necessary to undertake several transformations.

Senator SMITH of South Carolina. What is the new German process of extracting this ammonia and then converting it into nitrogen? Is it patented? Is it available for us at all?

Dr. NORTON. It was patented about 1909—the method of changing the nitrogen of the air directly into ammonia. We are dependent on patent rights in that connection for a few years yet.

Senator SMITH of South Carolina. Would it be feasible for us to make any arrangement with Germany, in case we were to embark in this, to avail ourselves of that process?

Dr. NORTON. It will be thoroughly feasible. The patents are held by a corporation, not by the German Government.

Senator SMITH of Georgia. Are they patented in the United States?

Senator SMITH of South Carolina. Have the German owners patented it in this country as well?

Dr. NORTON. Certainly. Every one of these processes is patented under out patent laws. The earlier cyanamid patents have already expired. The patents for the manufacture of nitric acid by the arc process will expire probably by 1920.

We have, however, gentlemen, I might state, a distinctively American process——

Senator SMITH of South Carolina. Doctor, by virtue of its directness, is this new process cheaper than the other—the cyanamid?

Dr. NORTON. It is not cheaper, as far as the nitrogen is concerned. If you look at it from the agricultural standpoint, all you want is to secure nitrogen in a combined form to introduce into the soil. It is cheaper, however, from the industrial point of view. If you want nitrogen in the form of nitric acid for explosives and the like, the arc method furnishes it directly by a single operation.

Senator SMITH of Georgia. You were about to say that there was one distinctively American process?

Dr. NORTON. There is one that I have alluded to in the next to the last paragraph of this article, published March 4. An American in 1903 presented an application for a patent for a method of fixing the nitrogen in the air. That application lay dormant in our Patent Office until August, 1915. It took 12 years to decide that the method was patentable. Everybody had forgotten about it. Four or five years after that application was presented, Prof. Haber, the German who developed the method of transforming the nitrogen of the air into ammonia, worked out on paper mathematically, and also in his laboratory, the possibility of increasing the yield of nitric acid in the arc process, by bringing in the element of pressure—which Dr. Rittman, of the Bureau of Mines, has, within the past year, utilized so effectively in transforming the residues of petroleum into gasoline and into benzene and toluene, to make picric acid, trinitrotoluene, etc. That was the fundamental idea of this patent application of 1903.

The method has now been worked out, and I might state, while the results have all been communicated to me in confidence, that the practical, industrial and technical results are away beyond what I ever dreamed of as being capable of realization. I have strong hopes that the process may be an important factor in the situation. We can not consider it now, but incidentally I have mentioned it in next to the last paragraph in this published article.

Senator SMITH of South Carolina. You spoke a moment ago as to the difference between the cyanamid process and the arc process. You mentioned that the arc process required a certain temperature and the cyanamid process a lower temperature. Does the one require greater power than the other?

Dr. NORTON. No. We require the electric current, but you do not need that tremendous installation in the cyanamid process, required to yield the very high temperature of the arc process. It is a much more economical plant. The operation is like that of an express train. If the train is running at a certain cost for fuel at 30 miles an hour and you want to increase that rate to 50 miles an hour, it is necessary to use more than twice as much fuel. It is the same in the case of an ocean greyhound; if you want to put on an extra mile per hour you have to use proportionately a very much greater amount of fuel. The same factor is involved in the differences between the cyanamid process and the arc process. In seeking to attain the tem-

perature at which the oxygen and nitrogen of the air are transformed into nitric acid, we need a relatively much more powerful plant. That means, we must have our fundamental source of electricity as cheap as possible. One can make cyanamid advantageously with electricity costing $20 a year per horsepower. The arc process can not compete, unless the rate falls to $3 or $4.

Senator SMITH of South Carolina. So, therefore, the cyanamid process is really cheaper than the arc process?

Dr. NORTON. It is cheaper from the standpoint of agriculture to get a product in which the nitrogen is contained ready for the use of the farmer. When we come to consider, however, the use of nitrogen in the form of nitric acid and nitrates, there, of course, you have the additional expense of transforming the nitrogen of the cyanamid into nitric acid.

Senator SMITH of South Carolina. Then, for agricultural purposes, Doctor, you would consider——

Dr. NORTON. Nitric acid made from cyanamid might compete with nitric acid made by the arc process. If the power employed for the arc process cost $7 or $8 or $10, nitric acid might be obtained as cheaply from cyanamid, made with electricity costing $20 per horsepower. These are some of the factors entering into consideration.

Senator SMITH of South Carolina. For practical purposes which of the two processes would you recommend under ordinary conditions for the production of fertilizer—the arc process or the cyanamid process?

Dr. NORTON. That would depend entirely on the fundamental cost. If the cost of water power is brought down very low, the arc process is the most advantageous, because it is more elastic. It supplies combined nitrogen ready for use as a fertilizer, ready for use in explosives, ready for use for industrial purposes—it is much more elastic. You have to compromise here and there. The problem must be worked out very carefully.

Senator JOHNSON of South Dakota. Can you use the arc process for fertilizer?

Dr. NORTON. Oh, certainly. The products of the arc process, in fact, serve for almost all the fertilizer used in Norway, and they are shipped to different parts of Europe for use as fertilizer.

Senator WADSWORTH. In what form is it shipped?

Dr. NORTON. As I mentioned a few moments ago, in the form of calcium salts. Chilean nitrate is a nitrate of soda. In Norway the nitric acid, obtained by the arc process, is put into a vat with ordinary limestone. This yields calcium nitrate, or nitrate of lime It is evaporated down to dryness, and is shipped to any part of the world.

Senator WADSWORTH. We had some testimony here yesterday to the effect that owing to the comparatively high cost of water power in the United States the arc process was impracticable for commercial uses. Have you any comment to make on that statement?

Dr. NORTON. That comes down practically to the cost of water power. At Niagara Falls the current cost is $20 per horsepower. I have myself determined, in my studies of the question, mentioned awhile ago, that if we can utilize the power of Niagara on a complete scale, the cost per horsepower might be a quarter of the present rate.

Senator WADSWORTH. When you speak of using Niagara Falls on a complete scale, you mean, of course, to use all the available water power there, on the ground that when you use it all it lessens the cost per horsepower?

Dr. NORTON. Yes.

Senator WADSWORTH. But, Doctor, you would not seriously suggest to this committee that we use all the Niagara power, would you?

Dr. NORTON. I would not hesitate at all to make that suggestion. In this article—the Scientific American, December 4, 1915—you have the idea elaborated. It affords a compromise between the surrender of Niagara Falls to the lovers of scenic beauty, or to those, constituting a majority of our population, who believe that it is not economically correct to have that latent power wasted every 24 hours. I have elaborated here the project for the entire utilization of Niagara Falls—7,400,000 horsepower—during the time when we are asleep, for 14 hours, from 8 o'clock in the evening until 10 o'clock the next morning. For 10 hours the lovers of scenic beauty can view the Falls exactly as they probably have been for 40,000 years, as they have worked their course backward from Lake Ontario to the present point.

In addition, I have suggested that while the Falls are in their normal activity it is possible to introduce a complete set of overshot wheels and utilize from one side of the Falls to the other, and from the base of the Falls to the top, as much as possible of the available power, perhaps 30 or 40 per cent of the total, without any of this mechanical equipment being visible to those who are gazing at the Falls. There will be a certain amount of additional spray, more of the rainbows around and above the Falls, etc. The idea is a new concept in engineering. It has never before been attempted—this idea of a dam above Niagara Falls, by means of which we can switch off the entire volume of water, and in one minute begin to generate seven and a half million horsepower. It involves the utilization of the 45 feet of the rapids above the Falls, the 167 feet of the Falls, and the 100 feet of the whirlpool rapids below, making a sum total of 312 feet of descent. That would give us an enormous power for 14 hours every day.

Senator SMITH of South Carolina. It would produce that horsepower during the 14 hours?

Dr. NORTON. Seven million four hundred thousand horsepower for 14 hours, and for 10 hours we could generate half of that while the Falls were in their normal state of activity, by placing this simple construction behind the curtain of falling water.

The CHAIRMAN. What would that installation cost?

Dr. NORTON. The estimate of the construction of the dam would be inside of $2,000,000. The average depth of the river for the three-quarters of a mile, from the American side to the Canadian side, is 3½ feet. There is a rock bottom. There is not the slightest engineering difficulty. From above this dam on both sides—it would naturally have to be an international matter—the water would be conducted 5 miles to the top of the bluff where there is a drop from the level of Lake Erie to that of Lake Ontario. There the power houses, etc., would be located. The penstocks and the rock tunnels, as we have them at Panama in connection with the canal locks, would descend to the base of the escarpment overlooking Lake Ontario.

I might state in this connection that if we take away from lovers of scenic beauty, for 14 hours in the day, the attractions of Niagara Falls, we would more than replace them. The interruption would largely take place when most people are asleep. We would enjoy the view of two of the most stupendous phenomena on the face of the globe. Every day would witness the birth and the death of a cataract.

I think, Senator, you can imagine the sight of the Niagara gorge, perfectly quiet while the Falls are harnessed; then, inside of one minute, a plunge into activity as the billows would sweep over the crest; the roar would begin, the spray would rise, the rainbows would spring into existence, and we would view a spectacle every day similar to that of the Johnstown flood or the Galveston tidal wave.

Senator SMITH of Georgia. What would be the total cost, and what would be the length of time required to put that suggestion into operation?

Dr. NORTON. It would not take over a year to build the dam. A year or two would be consumed in making the canals to connect with the bluff overlooking Lake Ontario. The construction of the power houses, etc., could go along simultaneously. I think, if an international agreement were ever reached between this country and Canada, inside of two or three years Niagara Falls could be harnessed completely, so that it could be either used for its scenic effect or devoted to the purely utilitarian interests of the two countries.

Senator SMITH of South Carolina. Doctor, I do not know that the committee have any other questions to ask, but you are so thoroughly familiar with the needs of our country in reference to fertilizer ingredients that I would like for you to speak on the possibilities of our potash development. We are as dependent on Germany for potash as we are upon Chile for nitrate.

Dr. NORTON. I notice on the table a copy of The American Fertilizer of March 4, containing my article, entitled "The Potash Famine." I might state briefly, gentlemen, however, that our whole agriculture depends upon three elements for its rations, its daily and annual rations: these are phosphoric acid, nitrogen, and potash. Our country produces a great abundance of phosphates, i. e., phosphoric acid. We even ship them abroad. We are dependent upon Chile, as you all know so thoroughly, for our nitrogen supply. We are dependent almost exclusively upon the mines in Stassfurt, Germany, for our supply of potash. We bring over to this country annually potash, in various forms, valued at about $17,000,000. We are dependent on a single source, which for the moment is cut off from the rest of the world.

Now, in our own country we have several sources of potash. The most abundant and widespread and economical of all these sources is in the kelp floating off the western coast of our country, all along the shores of Alaska, Washington, Oregon, and California. We have an annual crop which nature provides for us, worth $90,000,000, as far as the potash is concerned. It requires simply to be gathered, dried, and ground, and it is ready to ship to the cotton and tobacco fields of our Southern States.

Senator SMITH of South Carolina. About what per cent of potash is in that form when it is dried?

Dr. NORTON. For every pound of dried kelp we have to drive off eight and a quarter pounds of water. That dried kelp contains 19 per cent of potash. It corresponds with what is known to the fertilizer interests as the manure salts brought over in large amounts from Germany, containing 20 per cent of potash.

As I have recently shown, we can produce that dried kelp and lay it down in the ports of our Gulf and South Atlantic States for the use of the tobacco and cotton planters, and of the host of truck farmers in that region, at a cost per ton of $4 or $5 less than what we were paying before the war for the potash of Germany.

But, gentlemen, that is simply the potash. In addition to that, every ton of this dried kelp contains combined nitrogen ready for use for assimilation by plant life, just as valuable as Chile saltpeter or sulphate of ammonia or cyanamid. It contains enough of nitrogen to represent in prices current before the war a value of $5.50. We can supply our potash at an economy of several dollars on the ante bellum rates that we paid to Germany. In addition, there is in every ton $5.50 worth of combined nitrogen, replacing so much Chile saltpeter, and also 75 cents worth of phosphoric acid.

Senator WADSWORTH. Doctor, has anybody developed that at all?

Dr. NORTON. That has been done on a very elementary scale—tentatively. The chief difficulty has been the absence of legislation in California, Oregon, and Washington controlling the the 3-mile limit along the coast in which this kelp is found. Anybody who plans to erect large works for the collection and drying and shipment of this kelp is uncertain what the legislatures of those States may do the next week or the next day in laying taxes for franchises, or hindering in any way the ordinary exploitation. They are completely in the dark. There is the same absence of legislation regarding the entire coast line of Alaska and the Alaskan Islands. There needs to be Federal and State legislation which will enable capital to see its way perfectly clear to exploit on an enormous scale, commensurate with the needs of this country, this vast source of potash.

Senator SMITH of South Carolina. Would it not be more direct, on the same grounds that we are now trying to legislate, to supply this country with nitrogen, in view of the usage of potash almost pari passu with nitrogen, to solve this problem by providing proper legislation in writing this same measure?

Senator WADSWORTH. You mean to have the Government go into the business of gathering the kelp?

Dr. NORTON. I do not think the Government needs to go into the potash business. That is a very simple matter. It does not involve such elaborate machinery. It does not involve chemical processes. It is purely mechanical. We need only to run a submarine lawn mower through the water, collect the kelp, bring it to the coast, and dry it.

(Thereupon, at 12.05 o'clock p. m., the committee adjourned to meet at 10.30 o'clock a. m., Monday, March 20, 1916.)

WITHDRAWAL OF WATER-POWER SITES AND CONSTRUCTION OF WATER-POWER PLANTS FOR MANUFACTURE OF NITRATES.

TUESDAY, MARCH 21, 1916.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met at 10.30 o'clock a. m., pursuant to adjournment, Senator Thomas F. Gore presiding.

Present: Senators Gore (chairman), Smith of South Carolina, Smith of Georgia, Sheppard, Shafroth, Page, and Kenyon.

The CHAIRMAN. The committee will first hear Mr. Merrill, of the Forestry Service.

STATEMENT OF MR. O. C. MERRILL, CHIEF ENGINEER FORESTRY SERVICE, DEPARTMENT OF AGRICULTURE.

The CHAIRMAN. Please state your name, Mr. Merrill.

Mr. MERRILL. O. C. Merrill, chief engineer of the Forestry Service.

The CHAIRMAN. How long have you held that position?

Mr. MERRILL. Since 1909.

The CHAIRMAN. We shall be glad to hear any statement you wish to make concerning this matter.

Senator SMITH of South Carolina. Mr. Merrill, the committee have been very anxious to get data as to the available water-power sites in the United States, for the purposes of this proposed legislation. Now, there has been some difference of opinion as to what water-power sites have sufficient horsepower. I wish you would state to the committee what knowledge you have of these sites, the possibility of their development, and where they are located.

Mr. MERRILL. My familiarity with potential, undeveloped water-power sites is confined practically to the Western States. I have been not only with the Forest Service but with private parties in connection with water-power sites in the West for quite a number of years. I assume that for the purposes of this bill it is necessary to have a site of considerable horsepower, and one that can be developed at low cost. I have taken a map here that was prepared sometime ago by the Department of the Interior for another purpose, and have indicated by numbers in several places eight of the large and comparatively cheap water-power developments in the Western States.

Senator KENYON. Can you just enumerate them?

Mr. MERRILL. The first one is the site on the Pen d'Oreille River, in Washington, about 4 miles from the international boundary in

the northeastern corner of Washington. This probably has an available horsepower at ordinary stream discharge of about 150,000, and can be developed to 300,000 horsepower or more by means of storage farther up the stream. I do not know of my own knowledge at what figure this power can be developed, but I have been informed it is somewhere from $40 to $60 a horsepower, depending largely, of course, upon the amount that is developed at the site.

The CHAIRMAN. Do you mean that that includes the construction of the plant, or is that after the plant is constructed?

Mr. MERRILL. That would be the electrical end, the investment cost of the electrical part of the developement, dams, conduits, power houses, and the equipment for generating the power.

The CHAIRMAN. Can you estimate the annual cost of that after the plant is installed?

Mr. MERRILL. The two items would be the interest cost and the operating cost. The interest cost on, say $50 per horse power at 6 per cent, of course, would be $3 a horsepower year. Ordinarily, the operating expenses are about on an equality with the interest and sinking-fund charges, but for a development of this character, where the power is probably to be used directly at the site for electrochemical purposes it is quite probable that the operating charges will be in less proportion than they would be in an ordinary electrical system.

Senator SMITH of South Carolina. It seems to me it is important to get that distinction clear. In the ordinary electrical system the cost is in the transmission through lines and equipment at distant points.

Mr. MERRILL. That adds very largely to the investment cost in hydroelectric power systems.

Another site that I have indicated here is on the Skagit River, in northwestern Washington, on which developments of from 60,000 to 100,000 horsepower could be made, the difference depending on the amount of storage.

Senator KENYON. How far is that from the international line?

Mr. MERRILL. That is only a question of guesswork from the scale of the map. It is probably at least 100 miles. This is not as favorable a site as the Pend'Oreille site. The investment cost doubtless would be considerably greater, on account of the longer conduits that need to be constructed.

A third site which has been investigated for this purpose is a combination of power plants on the Sauk and Suiattle Rivers, also in Washington, where about 100,000 horsepower can be developed. I do not know what the probable investment cost on that system would be.

Senator SMITH of South Carolina. How much would be developed?

Mr. MERRILL. About 100,000 horsepower.

Senator SMITH of South Carolina. How far is it from the international boundary line?

Mr. MERRILL. That is still farther south. It is about in the middle of the State from north to south, about half the distance from the international boundary line to the Columbia River, and almost directly east, just a little north of east of Seattle.

There are two other sites on the Columbia River which have very large power possibilities. There is the Priest Rapids site, of which Mr. Pierce of Seattle has had a great deal to say before different committees of Congress and which is said to be able to develop from

400,000 up to approximately 1,000,000 horsepower, depending on the height of the dams constructed and the cost of installation.

The State of Oregon, in cooperation with the Reclamation Service, has investigated a site near The Dalles on the Columbia River, that has possibilities of about 500,000 horsepower.

Senator SMITH of South Carolina. Where is it located?

Mr. MERRILL. That is located on the Columbia River between Washington and Oregon, about the center of the State east and west.

Senator SMITH of South Carolina. And it is capable of developing how many horsepower?

Mr. MERRILL. About half a million horsepower. I believe they would have navigation in the river from there down. That is at Celilo Rapids, which is the lower development on the Columbia. Priest Rapids is farther up. This has been investigated by the State of Oregon in connection with the Reclamation Service. Had I known that I would be expected to give any information to the committee I could have looked up the details on that, because I have in my office copies of the reports that have been made on that site.

Senator SMITH of South Carolina. Have you any idea of the cost of horsepower at that development?

Mr. MERRILL. I do not remember, Senator, except that it is, as I recall, considerably cheaper than the developments that have already been made. I would not want to venture even a guess at it since figures can be secured.

There are two or more possibilities down in the State of California. On the north fork of the Feather River about the central part of the State there are power sites along about 20 miles of the north fork of the Feather River that could develop around 300,000 horsepower by the use of the Big Meadows Dam, which has been constructed by the Great Western Power Co. With a development up to that limit of 300,000 horsepower the cost per horsepower would probably be well under $100, possibly $80.

There are sites on the upper San Joaquin River in California being developed now by the Pacific Light and Power Corporation. The ultimate development proposed there is about 250,000 horsepower, and they have approximately 100,000 horsepower already developed.

Senator SMITH of South Carolina. Now, Mr Merrill, these power sites you have personal knowledge of?

Mr. MERRILL. Yes; I have personal information about them; some of them I have actually visited, but they are sites about which I have secured information in connection with the regular duties of my position.

Senator SMITH of South Carolina. Would your knowledge of the general topography of the country, east and south as well as west, lead you to believe that there is available water power, whether owned by the Government or otherwise, to develop 50,000 horsepower or more?

Mr. MERRILL. There are almost numberless sites where that can be done. There is one other site I have marked here, and that is at Polsom, at the outlet of Flathead Lake, in Montana. That is said to be capable of developing from 50,000 to 200,000 horsepower, depending on whether the natural flow alone is utilized or whether a draw down of about 10 feet from the lake is utilized. I have not seen any figures

of probable cost at this site, but I am informed that it is a comparatively cheap development.

There are eight sites that I have picked out——

Senator KENYON. In four States?

Mr. MERRILL. In four States—Washington, Oregon, California, and Montana.

The CHAIRMAN. You are not familiar with those in the East and North?

Mr. MERRILL. I am not familiar with those in the East and North except by what I have read about them. The amount of available water power is far greater in the West than in any other section.

(Here ensued informal discussion which the reporter was directed not to take.)

Senator SMITH of Georgia. Do you know anything about that plant that furnishes potash in the West?

Mr. MERRILL. No, Senator; I am not familiar with that.

Senator SMITH of Georgia. Who in the Agricultural Department would know most about that?

(At this point Mr. Brown, who was present in the committee room, made the following statement at the instance of the committee:)

Mr. BROWN. My name is Brown. I am from the Bureau of Soils, in charge of fertilizer investigations. You mean the plant that is handling the alunite deposits in Utah?

Senator SMITH of Georgia. No; the plant on the Pacific slope that is supposed to contain such great quantities of potash—not a manufacturing plant.

Mr. BROWN. You mean the kelp?

Senator SMITH of Georgia. Yes.

Mr. BROWN. Well, it is on the coast. There are half a dozen of them. The Swift Fertilizer Co. is one. The Hercules Powder Co. is another. The Diamond Match Co. is a third, and there are three or four others.

Senator SMITH of Georgia. It was about the kelp as the growing plant, not the manufacturing plant, that I was asking the quantity of the kelp and the quantity of potash that it produces.

Mr. BROWN. Well, it produces a very remarkable quantity of potash—just the kelp as it comes out of the sea is run through a drier and ground. That stuff can be used as a fertilizer, and if it occurred on the Atlantic coast it would be a fine source of fertilizer as it is. It contains from 16 to 25 per cent of potash, but the trouble is it is so bulky.

Senator SMITH of Georgia. What is the balance of it?

Mr. BROWN. Organic material. It contains about 2 per cent nitrogen in addition, which increases its value.

Senator SMITH of Georgia. And the balance of the organic material is a good fertilizer?

Mr. BROWN. The nitrogen is good fertilizer, and there is a certain amount that goes to humus and improves the physical condition of the soil to that extent.

Senator SMITH of Georgia. You say there are several companies engaged in producing potash from it?

Mr. BROWN. Yes; they are putting in a good deal of money, but in our judgment they are not using the right method. They are drying and grinding the stuff, and the Swift Co. is now shipping

something like 2 or 3 tons a day of this dried ground kelp to Chicago by freight from San Diego. As a result, when they get it to Chicago it is a pretty high-priced fertilizer.

The CHAIRMAN. If it came through the canal it would come a good deal cheaper, would it not?

Mr. BROWN. I do not know exactly what the freight rate is to Chicago by rail.

(At this point the hearing was suspended for a few minutes to permit members of the committee to answer a call of the Senate.)

Senator SMITH of South Carolina. Now, Mr. Merrill, you have given the committee all of the water-power sites that you are familiar with in that region that would, in your judgment, be available for the purpose of this bill?

Mr. MERRILL. No; I have merely picked out eight of the sites that I think would probably be the cheapest and furnish a large amount of power. There are scores of sites that might possibly be used.

Senator SMITH of Georgia. Have you given the power in each?

Mr. MERRILL. Yes; the approximate amount of power.

Senator SMITH of Georgia. And what is the largest?

Mr. MERRILL. The largest, I think, that I have here is about half a million.

Senator SMITH of Georgia. And that is where?

Mr. MERRILL. That is at The Dalles, on the Columbia, between Oregon and Washington.

Senator SMITH of South Carolina. Now, Mr. Merrill, have you any knowledge of the fact that there are other water-power sites in this territory?

Mr. MERRILL. Oh, there are other sites there; no doubt there are many other sites.

Senator SMITH of Georgia. What is the best site east of the Rockies?

Mr. MERRILL. I would not be able to answer that, Senator.

Senator SMITH of Georgia. The sites you have given are west of the Rockies?

Mr. MERRILL. They are west of the Rockies. I am not familiar with the sites down here in the South Atlantic States.

Senator SMITH of Georgia. I mean, are there any in the West east of the Rockies that you know of that would be large enough?

Mr. MERRILL. I doubt that there are, without combining several sites together. Practically all of the large power sites in the West are either on the upper Missouri or on the Columbia and its tributaries or the Sacramento and its tributaries.

Senator SMITH of Georgia. And what about the upper Missouri?

Mr. MERRILL. There are sites on the upper Missouri. The Montana Power Co. has just constructed a plant that will have a development of about 100,000, as I recollect, at the Great Falls of the Missouri.

Senator PAGE. That is the city of Great Falls in Montana?

Mr. MERRILL. No; it is at what is known as the Great Falls, 10 or 12 miles below the town. There is a big drop. The site nearest the town of Great Falls is what is called Rainbow Falls.

Senator PAGE. What have you to say about the east Tennessee power that has been referred to in some of the previous hearings?

Mr. MERRILL. I am not familiar with the power in the South Atlantic States.

Senator PAGE. You agree with the gentleman who spoke to us here the other day that 300,000 is the minimum horsepower required?

Mr. MERRILL. I could not say; I have not examined that.

Senator SMITH of Georgia. You are not an expert on the production of the nitrogen?

Mr. MERRILL. No.

Senator SMITH of Georgia. You are in the Forestry Service, and you know these western water powers?

Mr. MERRILL. Yes; and that is all that I wished to speak about.

Senator PAGE. What did you say was the power at The Dalles?

Mr. MERRILL. Why, it is somewhere around a half a million horsepower, but it depends on the height of the dam that is constructed.

Senator PAGE. And that is the minimum?

Mr. MERRILL. I understand that that is the amount the engineering board which made the estimates reported as a development.

Senator PAGE. I understand that in the manufacture of nitrogen we must rely upon a continuous power, and the minimum at all times must be the power to be taken into account. Now, when you say 500,000 horsepower at The Dalles, do you mean that is the minimum, the maximum, or the average?

Mr. MERRILL. I mean that would be the minimum with the height of dam proposed. That is my understanding.

Senator PAGE. At low water?

Mr. MERRILL. Yes; that is my understanding.

Senator SMITH of South Carolina. Senator Page, I would like to call your attention to the remark you made a moment ago to the effect that it had been testified here that not less than 300,000 horsepower should be available for the production of this nitrogen. Dr. Norton, the expert on this matter in the Department of Commerce, says that 50,000 horsepower would be the minimum.

Senator PAGE. I referred to the suggestion of the president of the Niagara Falls Co., who said 300,000 horsepower.

Senator SMITH of Georgia. To handle the arc system——

Senator SMITH of South Carolina. As contradistinguished from the cyanamid system?

Senator PAGE. We have any number of powers even in New England where we can develop 30,000.

The CHAIRMAN. He said he was operating with 27,000.

Senator SMITH of South Carolina. Do you know, in any coordinate department of the Government, anyone who would be familiar or should be familiar with all of the water powers, regardless of whether in a Government reservation or elsewhere in the United States?

Mr. MERRILL. I do not know of any one individual.

Senator PAGE. Would not the Geological Survey have that?

Senator SMITH of South Carolina. They indicated to me that they did not. I would like to exhaust this subject, but upon communicating by telephone with the various departments Dr. Merrill was the only one indicated to me by any of the departments who would have a knowledge of this matter as to the water powers of the United States. Now, we have developed the fact that 30,000 horsepower can be used in the manufacture——

Senator SHEPPARD. Was there not a census taken in 1910?

Senator SMITH of Georgia. My own judgment is about 100,000, from the testimony, unless we use the latest system.

Senator SMITH of South Carolina. Dr. Merrill has testified that, from his knowledge of it, that would be sufficient. What is your idea, Doctor?

Mr. MERRILL. It simply depends on how much you want to produce. That is really the whole story, of course.

The CHAIRMAN. If nobody has ever done this we certainly ought to see that somebody does do it.

Senator SHEPPARD. I asked the question a moment ago whether any census of the water powers of the United States has ever been taken?

Mr. MERRILL. The Geological Survey in 1908 made an estimate of the potential water powers in the United States. In 1912 the Commissioner of Corporations made a revision of that, and in the recent report to the Senate on electric power development in the United States, I made certain revisions of that report and of the Geological Survey report, with new figures for Idaho. That report will give you the latest and best information that the Government has in any department. This report is now being printed. Part 2 will probably be out in two or three weeks as Senate Document No. 316 of this Congress. It is in proof sheets now. In the Part 2 that is coming out is a census up to three months ago of the developed water power in the United States. I could furnish the committee with photographic copies of that portion of the report relating to potential water power.

The CHAIRMAN. I wish you would do that.

Senator PAGE. Senator Smith of South Carolina, may I ask you what is the value per ton of this product which we are supposed to produce from the atmosphere, do you know how much could be made with 30,000 horsepower?

Senator SMITH of South Carolina. I do not know how much could be made with 30,000 horsepower. I know that the nitrate of soda, which is equivalent of this which we propose to reduce, is retailed at about $50 to $55 a ton. Those were ante bellum prices.

The CHAIRMAN. Mr. Washburn said he was turning out 60,000 tons a year with 27,000 horsepower.

Senator SMITH of South Carolina. Dr. Norton testifies that it can be produced for about $17 to $18 a ton.

Senator SMITH of Georgia. The price per ton at which you would produce it would, of course, be affected by the quantity of the production and the location and the other things to be used besides the air. You must locate with limestone easily accessible, and coke easily excessible, as both of those are necessary, and the real problem of economical production involves horsepower and the other things than air that are required to accomplish the production.

STATEMENT OF MR. FREDERICK W. BROWN, IN CHARGE OF FERTILIZER INVESTIGATIONS, BUREAU OF SOILS, DEPARTMENT OF AGRICULTURE.

Senator SMITH of Georgia. Now, Mr. Brown, what is the amount of potash produced by these plants now on the Pacific slope?

Mr. BROWN. Their present production is very small. I had a report from a man on the coast within the last two weeks, and I think the total production from the plants that were up was something

like four or five tons a day. That, of course, does not scratch the surface of the problem.

Senator SMITH of Georgia. To what do your attribute this small production?

Mr. BROWN. Several of them are not actually in operation. The whole business is very young. It has started within the last few months. I think the Swifts, for instance, have gone in simply to preserve their brands. They have a certain number of brands that contain potash, and they can not get potash anywhere else, so they have gone to the Pacific coast, and they are producing it there at any cost. The Armour Fertilizer Co. has gone to the alunite deposits in Utah.

Senator SMITH of Georgia. What is the form of that?

Mr. BROWN. It is a rock from which potash can be secured simply by roasting.

Senator PAGE. I believe that produces only about 8 per cent of potash?

Mr. BROWN. No; I think it contains 11.

Senator SMITH of South Carolina. Yes; it is that and higher.

Senator SMITH of Georgia. I wish you would deal especially with the kelp.

Mr. BROWN. The kelp looks to me, Senator, like the most likely source of a potash supply sufficient to meet the needs of this country, both for fertilizers and for the arts. That the kelp contains potash there is no question; it contains it in large quantities.

Senator SMITH of Georgia. What is the limit of supply of this kelp?

Mr. BROWN. It is almost unlimited. There are millions of tons of it there.

Senator SMITH of Georgia. Does it grow each season, or does it come down each season?

Mr. BROWN. No. The Bureau of Soils charted the area, and it is almost a continuous growth extending from San Diego right on up the coast to Alaska and on around the peninsula.

The CHAIRMAN. How wide is it?

Mr. BROWN. It is almost all within the 3-mile limit, Senator. It grows, however, in depths as great as 100 feet. It has a holdfast at the bottom, and it comes up in a long streamer to the top.

Senator PAGE. Is it possible to make potash from kelp as cheaply as it can be produced in Germany after the war closes?

Mr. BROWN. We have never had an appropriation to conduct experiments on anything more than a laboratory scale. Our experiments on the laboratory scale would indicate that it is possible. It is probably true that in time the German syndicate, if they saw competition arising, would drop their prices. I think we would no longer get muriate of potash at $40 a ton as we did before the war. I think they could sell it considerably lower. I think very likely they would sell it below cost in order to put the competition out of business.

Senator SMITH of Georgia. What is the cost of transportation per ton from this point on the Pacific coast around to the eastern coast by water?

Mr. BROWN. Through the canal prior to the war it was $6 a ton—these are approximate figures. Just prior to the closing of the canal,

however, it was nearly $12—$11.75, perhaps. I do not know the rate through the canal now. The companies have all canceled their rates because the canal is closed. When it is reopened, the price, owing to the lack of available tonnage, will probably be close to $12.

Senator SMITH of South Carolina. Have you any knowledge as to the cost of production of a ton ready for shipment? I think Dr. Norton gave some figures, and I would like to hear yours.

Mr. BROWN. I do not know that there are any figures available, because it has never been produced on a commercial scale except by these companies that have just begun.

Senator SMITH of Georgia. Do they separate the potash from the other material?

Mr. BROWN. They are just grinding it and shipping it. Now, the better way, I think, in view of the long freight haul to the eastern seaboard where the potash is demanded, would be to separate it by some chemical process that would give the salts and ship merely that much bulk.

The CHAIRMAN. Do you know whether any experiments have been made as to the concentration of it that way?

Mr. BROWN. We have made experiments in our laboratories. It can be done.

The CHAIRMAN. But you have no way of arriving at the cost?

Mr. BROWN. We have no way of arriving at the cost, because we have nothing but a laboratory.

Senator SHEPPARD. Have you not an electric furnace in operation?

Mr. BROWN. We have, over at Arlington, just started.

Senator SHEPPARD. You are trying to develop phosphoric acid?

Mr. BROWN. Yes; and nitrogenous products. But that is another proposition.

Senator SHEPPARD. They are elements in fertilizer, too, are they not?

Mr. BROWN. Yes.

Senator SMITH of Georgia. Let us finish with potash first and come back to that afterwards. We are trying to develop this potash proposition.

Senator SHEPPARD. Very well.

Senator SMITH of Georgia. Now, will any legislation be necessary to facilitate the utilization of this material in the 3-mile limit?

Mr. BROWN. My understanding is it is in the hands of the States. Anybody can go now and help himself. Until the States, or the counties, possibly, in the absence of State legislation, adopt some measures for leasing the beds there is no guarantee that private capital will be protected.

Senator SMITH of Georgia. Do the States on the Pacific coast control the product in the 3-mile area or does the United States?

Mr. BROWN. My understanding, Senator, is that the States control it.

Senator SMITH of Georgia. That is covered by the grant, or by the constitutions of the States?

Mr. BROWN. I think it is under State control. No one of the three States has taken action. We tried very hard to get California to do so this winter.

Senator SMITH of South Carolina. Have you any knowledge of what rights under the circumstances the Federal Government would have within that 3-mile limit?

Mr. BROWN. I do not think there is any question but what now in the absence of State legislation the United States could walk right in and help themselves. Anybody can. As a matter of fact, these people are doing it.

Senator SMITH of Georgia. Does it reach to the lower end of California?

Mr. BROWN. It goes away on down to Lower California along the Mexican coast.

Senator SMITH of Georgia. And there is an ample supply, then, as far south as the southwestern corner of the United States?

Mr. BROWN. Yes, sir; some of the largest beds are right off San Diego.

The CHAIRMAN. Do they need a great deal of fuel in converting it?

Mr. BROWN. No; not a great deal. If you dry it and grind it, it involves a certain expenditure of coal or fuel oil, or something of that kind.

The CHAIRMAN. They have employed oil in California?

Mr. BROWN. Yes; I think they are using oil in the driers they are using out there now.

Senator SMITH of South Carolina. Section 4 of this bill provides:

> That the Secretary of Agriculture is authorized to lease, purchase, or acquire, by condemnation, gift, or devise, such lands and rights of way as may be necessary for the construction and operation of such plants and to take from any lands of the United States or to purchase or acquire by condemnation, materials and minerals necessary for the construction or operation of such plants and for the manufacture of such products.

The products referred to are the fertilizer ingredients, "nitrates or other products useful in the manufacture of fertilizers and munitions of war." Under the terms of this bill, then, the Government might erect such plants as are required to produce potash in commercial quantities——

Mr. BROWN. No; not potash. I wish it did include potash.

The CHAIRMAN. How is that?

Mr. BROWN. I think this bill does not cover the potash situation at all. It says "such power sites." Now, the first section limits it to power sites. The second section limits it to power sites in the public lands and such mineral sites in the public lands as contain limestone, phosphate, coal, or other minerals needed for the production of nitrates or other products as contemplated in this act.

Senator SMITH of Georgia. What sum would it take to enable the Secretary of Agriculture to test out this potash proposition?

Mr. BROWN. We compiled figures which showed we could put up a plant on a commercial scale that would handle, I believe, 500 tons of wet kelp per day. That would deliver about 50 tons—I am not certain about the amount—of the dried kelp. It would cost about $150,000, Senator.

Senator SMITH of Georgia. Is that all?

Mr. BROWN. If we had that we could handle 500 tons. Understand, that would not begin to supply the country.

Senator SMITH of Georgia. I am not suggesting that you supply the country. I am suggesting a demonstration that will cause private capital to go into it and supply the country.

Mr. BROWN. Exactly. That would offer us an opportunity to demonstrate absolutely the possibility or want of possibility. It might turn out that it can not be done. We think it can.

Senator SMITH of Georgia. An appropriation of $150,000 for test purposes, you think, would enable you to do it? Within what time?

Mr. BROWN. That is a difficult question to answer, because it is very hard to get delivery of machinery nowadays, especially on the Pacific coast.

Senator SMITH of Georgia. Do you think you could do it in 12 months?

Mr. BROWN. I should hope we could come back with some results in 12 months.

Senator SMITH of Georgia. And you think a plant of that size would enable you to deliver 50,000 tons a day?

Mr. BROWN. No; we would handle 500 tons of the wet kelp per day. About one-sixth or one-seventh of that would be dried kelp. That would give us 70 tons of dried kelp a day. That dried kelp will run 25 per cent potash salts. A quarter of 70 is 18. That would give us 18 tons of potash salts a day.

Senator PAGE. That would be about $360 worth a day?

Mr. BROWN. That is 18 tons of KCl, and at normal prices that is worth $40 a ton.

Senator SMITH of Georgia. But that price of $40 is for delivery on this side?

Mr. BROWN. Yes; that is for delivery on this side.

Senator SMITH of South Carolina. The question I wanted to ask you was this: How much would be necessary to erect a plant to extract the concentrated salt so as to avoid the heavy freight in shipment? Now, we get muriate of potash from Germany. In your opinion, what would be necessary to conduct along with that the concentration of the salt so as to ship it in concentrated form.

Mr. BROWN. That is exactly what we proposed to do, to ship the salt. That figure of 18 tons refers to the salts.

Senator SMITH of South Carolina. Not the dried, ground kelp?

Mr. BROWN. No; you would get about 60 or 70 tons of the dried, ground kelp.

The CHAIRMAN. Do you estimate that the added cost of producing it from the bulk form to this concentrated form would be less than the freight on the bulk?

Mr. BROWN. Yes, indeed; very much less.

Senator PAGE. Is it not true that in the manufacture of fertilizers you need a mixture; for instance, ground rock?

Mr. BROWN. Quite so, but the phosphate will supply that, and the potash and nitrogen can go in in comparatively concentrated form.

Senator SMITH of Georgia. If you did not make the separation, if you carried the whole across the country you would have to carry 52 tons of the other stuff to 18 tons of the salt?

Mr. BROWN. Exactly.

Senator SMITH of Georgia. At $6 a ton it would cost you for that 52 tons $312 to get that stuff around, and it is not worth anything like that on the other side?

Mr. BROWN. It is worth a little for its nitrogen content.

Senator SMITH of Georgia. So it is essential to test out the separation to demonstrate its commercial value?

Mr. BROWN. I think so.

Senator SMITH of Georgia. You have no idea, have you, what it would cost you to produce this 18 tons per day?

Mr. BROWN. No. We have no accurate figures, Senator, and we are not able to get them. We have struggled to get some accurate figures. We sent a man out there to the coast to visit these plants and try to get cost data, but they have been in operation such a short time they have not got their processes shaken down.

Senator SMITH of Georgia. Have you discussed it with the Secretary of Agriculture at all?

Mr. BROWN. Yes, sir; we have talked it over.

Senator SMITH of Georgia. How does he feel about a special appropriation of $150,000 to test this process out?

Mr. BROWN. I can not say, Senator. I ought to say that no estimate for this was included in the department's estimates.

Senator SMITH of South Carolina. What per cent of potash did you say a moment ago was in the concentrated form?

Mr. BROWN. In the dried kelp?

Senator SMITH of South Carolina. No; I mean when you have extracted the potash salt from the kelp.

Mr. BROWN. Then you have chloride of potash, potassium chloride, 80 per cent pure. That is exactly what we get from Germany.

Senator SMITH of South Carolina. I thought in answer to one of the queries here you said 20 per cent.

Mr. BROWN. No. What I meant to say was this, that the dried kelp contained 25 per cent potash.

Senator SMITH of South Carolina. But the extracted form contains 80 per cent?

Mr. BROWN. It is 80 per cent pure. That is right.

Senator SMITH of South Carolina. You have charge of the fertilizer investigations?

Mr. BROWN. I have charge of the fertilizer investigations, but I have specialists under me who handle these various sections of it. Mine is an administrative position, and I do not carry the details in my head.

The CHAIRMAN. Is it your judgment, Mr. Brown, that by the use of water power, the fixation of nitrogen, and this kelp and other resources available here, we can make fertilizer here at a price that will enable us to meet reasonable competition from Germany and other countries?

Mr. BROWN. I do not see any reason in the world why we should not.

The CHAIRMAN. Of course I am excluding dumping, because that is unreasonable competition.

Mr. BROWN. From our investigations there seems to be no reason why we should not do it.

Senator SMITH of Georgia. I have no doubt that we will be producing nitrogen at an early period for our fertilizers, but we want to get potash also.

Mr. BROWN. There you run right into the necessity of making some arrangement or other with the holders of the patents. The existing processes for fixing nitrogen by the electric furnace are all patented up to the hilt, and some arrangement would have to be made with the holders of those patents. The best chemists in the world have been working on that for years, and these processes that are in operation are the ones that have been worked out thus far.

Senator SMITH of Georgia. Do you know anything about the third process that is used in Germany that requires very much less power?

Mr. BROWN. There is talk of what they call the Haber process, I believe, which is the direct combination of hydrogen and nitrogen to form ammonia. The details of that process I do not know.

The CHAIRMAN. Do you know anybody that could enlighten us on that subject?

Mr. BROWN. I instructed one of my men to find out something about it the other day if anything was available. He told me at the time that he thought some of the details of that process had not been patented; they had simply been kept secret. But the general idea is well known, and I have hopes that we can work that out in time and find out how it is done.

Senator SMITH of South Carolina. Mr. Brown, you do not know whether or not any officer of the Army would have anything like an expert knowledge of this method as applied to explosives?

Mr. BROWN. I do not know. One of the Army officers testified before the Military Affairs Committee of the House on the Mussel Shoals proposition and gave some figures about how much it would cost to develop 125,000 horsepower. The processes I do not know. I have no knowledge whether they have anything on that or not. I should think the ordnance officers would.

Senator SHEPPARD. Did you tell us about your production of phosphoric acid with nitrogenous products, or will you tell us?

Mr. BROWN. We are working over at the farm on the idea; I have with me the electrochemical expert who has charge of that, Mr. Carruthers, if you would like to have a statement from him. He is working on the problem of producing phosphoric acid and fixed nitrogen in the electric furnace in one operation. We put the phosphate rock in the furnace with coke, and the fumes pass off and are absorbed in an absorption tower, forming phosphoric acid direct without the use of sulphuric acid at all, as in the ordinary process where a certain amount of the rock is treated with sulphuric acid to produce phosphoric acid.

Senator SHEPPARD. Is phosphoric acid as essential an element in fertilizer as potash?

Mr. BROWN. Oh, yes. In an ordinary fertilizer formula, 10-2-2, the 10 represents phosphoric acid, 2 is nitrogen, and the other 2 is potash.

Senator SHEPPARD. Where have we been obtaining our supplies of phosphoric acid heretofore?

Mr. BROWN. There are tremendous beds in the South, in Tennessee, South Carolina, and Florida.

Senator SHEPPARD. Are they being developed on a satisfactory scale?

Mr. BROWN. Oh, yes. We do not import a pound of phosphate rock.

Senator SMITH of Georgia. We ship the material for phosphoric acid to foreign countries.

Senator SMITH of South Carolina. That is the cheapest stuff we have, and we have an unlimited supply of that.

Senator SHEPPARD. Then why is the United States Government working on that?

Mr. BROWN. This is a combined process.

Senator SHEPPARD. This is to develop a new and inexpensive process?

Mr. BROWN. A new process.

Senator SMITH of Georgia. You are studying the problem of a less expensive process, to cheapen the commodity?

Mr. BROWN. Exactly.

Senator SMITH of South Carolina. You are attempting to get rid of the sulphuric acid process in producing phosphuric acid?

Mr. BROWN. Yes. That is very important now, because sulphuric acid has gone from $5 a ton to $25 a ton.

Senator SHEPPARD. I notice this sentence in the report of the Secretary of Agriculture:

> A phosphoric-acid plant, exclusive of the hydraulic and hydroelectric equipment, located in the western fields, to test the possibilities of utilizing the western phosphate beds by the use of hydroelectric power would require an appropriation of approximately $100,000. For operating expenses for one year, $25,000 would be required, with the provision that the products should be disposed of at the market price and the proceeds returned to the plant for operating expenses.

Senator SMITH of South Carolina. That is the very plant he was speaking of.

Mr. BROWN. No; there were two. One was the kelp plant and the other was the phosphoric-acid plant that we hope to demonstrate the possibility of.

Senator SHEPPARD. Is phosphoric acid being produced now by water power?

Mr. BROWN. Not to any extent. Phosphoric acid is obtained by taking the phosphate rock and treating it with an equal amount of sulphuric acid.

Senator SHEPPARD. That is an expensive process, is it?

Mr. BROWN. It is expensive just now because sulphuric acid has been so largely taken up by ammunition plants that it has gone from $5 a ton to $25 a ton.

Senator SHEPPARD. What percentage of nitrogen do you get in this electric furnace?

Mr. BROWN. We have not got any—at least, practically none—because we have just started.

Senator SHEPPARD. What do you hope to get?

Mr. BROWN. We hope to get any amount we can. I do not know. In the cyanamid process they get 20 per cent, and our process is similar to the cyanamid process.

Senator SMITH of Georgia. The process you are using is one that has been patented?

Mr. BROWN. It is patented. The combined process is not. If we can get a combination I think we can get a patent, but still there is a basic patent——

Senator SMITH of Georgia. Controlled where?

Mr. BROWN. Controlled by the Cyanamid Co.

The CHAIRMAN. What process is that?

Mr. BROWN. The production of the carbide that is involved in the cyanamid process.

The CHAIRMAN. How far are these phosphate beds in the West from the seaboard?

Mr. BROWN. They run down through Montana, Idaho, Wyoming, and Utah, I believe.

The CHAIRMAN. I was wondering if they were close to the kelp beds.

Mr. BROWN. No. They are not very far from the alunite deposits where there is a source of potash.

The CHAIRMAN. How far would you say?

Mr. BROWN. They run into northern Utah, and the alunite deposits are in the southern central part of the State.

Senator SMITH of Georgia. These deposits, however, have to be transported to the eastern coast by rail, which will be expensive. The real problem is to handle the weed on the coast and send it by water.

Mr. BROWN. Of course, you reduce your cost if you can do it that way.

Senator SMITH of Georgia. And that is the proposition you gentlemen have especially on your minds, is it not?

Mr. BROWN. I have it especially on my mind. I believe the kelp is really possible as a source of potash, and I believe this country ought to be independent of any foreign country for its potash.

Senator SMITH of South Carolina. I am rather of the opinion of Senator Smith of Georgia that we are going to solve the nitrogen problem. Now, if we can solve the potash process, we have already solved the phosphoric acid. In my State we can produce it when sulphuric acid is cheap, as it was before the war, at from $7 to $8 a ton. The fact of the matter is that we have demonstrated that where you have a lot of vegetable matter in the soil you can take the phosphate rock and put it in the soil, and the chemical action of your decomposing plants will produce phosphoric acid in the soil.

Mr. BROWN. There are indications that that is the case.

Senator SMITH of South Carolina. What amendment to this bill would you suggest to cover that matter of the potash?

Mr. BROWN. I saw this bill while it was being drafted in Mr. Caffey's office, and I raised the question then that it did not take care of the potash side of the matter at all, but it was a power-plant bill, and there is no power-plant question involved in the potash or kelp. Nothing was done about it. It would simply require an additional section authorizing the work on the kelp.

Senator SMITH of Georgia. I want to suggest, Mr. Chairman, to the Senator from South Carolina that the nitrogen problem is a very big problem and a difficult one to put through. This potash problem, which only requires an appropriation of $150,000 to let the plant be built and tested out by the Agricultural Department, is so important that I think we ought to take it by itself and put it right through and send it over to the House. I do not think we need wait for the general appropriation bill. I think the situation is such as to justify us in passing a special bill authorizing that appropriation.

Senator SMITH of South Carolina. It has been indicated before this committee that the reason it could not be developed was because there could not be obtained proper legislation to give one concern sufficient leeway.

Mr. BROWN. I think that is a perfectly fair reason from the manufacturer's standpoint, too. A man ought to have a right to lease a bed or to buy the profit of that bed for a term of years, at least. Otherwise he has no guarantee that when he has erected his plant

somebody else will not come in within the 3-mile limit and walk off with his kelp.

Senator Smith of Georgia. Will the beds continue to furnish a supply while they grow up?

Mr. Brown. The southern kelp apparently renews itself in about three months according to the best figures we can get on it. The northern kelp, along the Oregon and Washington coasts, is an annual. If cut it returns the following year.

Senator Smith of Georgia. What is the total amount of potash used annually?

Mr. Brown. From 900,000 to 1,000,000 tons.

The Chairman. You mean the concentrated form.

Mr. Brown. Yes.

Senator Smith of Georgia. That is what I am talking about. So, to produce 100,000 tons annually, how large a plant would you need?

Mr. Brown. It would take a pretty good sized plant, Senator. This plant that I speak of, producing 18 tons a day, would produce 5,400 tons a year.

Senator Smith of Georgia. Then it would take about a $2,000,000 plant to put out 100,000 tons a year?

Mr. Brown. Offhand, I should say at least that.

Senator Smith of Georgia. How much area would be required of the kelp to produce 100,000 tons a year?

Mr. Brown. That is hard to say, because the beds are not uniform in growth. Some are thick and some are thin.

Senator Smith of Georgia. Take the largest beds in southern California.

Mr. Brown. I could not say. I can get the figures, but I can not say offhand how much it would take. I do not know how much can be harvested per acre.

Senator Smith of Georgia. Have you information in the department that covers this?

Mr. Brown. Yes.

Senator Smith of Georgia. I wish you would let us have that.

(Information subsequently furnished by Mr. Brown:)

The investigations of the Bureau of Soils indicate that between 17 and 18 square miles of kelp beds of average thickness would be required to produce 100,000 tons of salts.

The Chairman. Does not that stuff grow anywhere on the Atlantic seaboard or the West Indian Islands?

Mr. Brown. No; it does not occur anywhere except along the Pacific coasts.

The Chairman. Has there been any effort made to transplant it?

Mr. Brown. No. That is one thing I have on my mind. I want to try that. I want to get the Bureau of Fisheries to bring some across on their cars—some of the spores.

Senator Smith of Georgia. Has the experiment been tried of cutting it to see if continued cutting will destroy it?

Mr. Brown. One of the fish-cannery plants on either the Oregon or the Washington coast tried their best some years ago, I am told, to clear a channel through that kelp and keep it clear, and the stuff came up faster than they could keep it cut.

Senator SMITH of Georgia. So you are not uneasy about that end of it?

Mr. BROWN. Not in the least. I think there is no question about it renewing itself after being cut.

Senator PAGE. I believe there are large manufacturers of fertilizer in this country that would not hesitate to put $1,000,000 into your plant if they could produce an element of this kind at anywhere the the prices suggested.

Mr. BROWN. As a matter of fact some of those plants are putting in pretty heavy investments. The Hercules Powder Co., I think, has a half million-dollar project out there.

Senator SMITH of Georgia. Where is it located?

Mr. BROWN. It is down in southern California. All these plants, in fact, except one up near Seattle, are down in the southern part of California.

Senator SMITH of Georgia. Have they tested the question of the separation of the salts?

Mr. BROWN. I think not. So far as my information goes the only thing that is being produced now is this dried, ground kelp.

Senator SMITH of Georgia. Can you find out whether any of them are endeavoring to solve that?

Mr. BROWN. I have a man out there who is keeping me advised, but the Hercules plant is not up yet. They are putting in $500,000, but they have not got the plant up.

Senator SMITH of Georgia. It would be vastly better for the department to find a way to do that and make it public to everyone than to let one company do it.

Mr. BROWN. I think so.

Senator SMITH of Georgia. What you do is for all the people.

Senator SMITH of South Carolina. This potash is an ingredient that enters into explosives as well as nitrogen?

Mr. BROWN. Yes; I am informed that for some explosives potash is used.

Senator SMITH of South Carolina. I want to have that developed here.

Mr. BROWN. In fact, I do not think the Hercules Powder Co. would be out there on the coast if it were not needed in explosives.

Senator SMITH of South Carolina. Mr. Brown, you are familiar with the situation. What appropriation would, in your judgment, be necessary to try it out on a commercial scale? Will you just draft and send back immediately what you think would be the proper form in which to put a measure before the Senate in order to cover this very point of testing out the process of manufacturing potash from kelp?

Mr. BROWN. You mean as a special bill or as a section of this bill?

Senator SMITH of South Carolina. Both.

The CHAIRMAN. We can utilize it anyway. I think it ought to be presented as a special bill.

Senator SMITH of South Carolina. Will you send that up not later than to-morrow, if you can possibly do so?

Mr. BROWN. I will try to get it here to-morrow.

(Thereupon, at 12.10 o'clock p. m., the committee adjourned to meet at 10.30 o'clock to-morrow morning.)

WITHDRAWAL OF WATER-POWER SITES AND CONSTRUCTION OF WATER-POWER PLANTS FOR MANUFACTURE OF NITRATES.

WEDNESDAY, MARCH 22, 1916.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee assembled at 10.30 o'clock, a. m., pursuant to adjournment.

Present: Senators Gore (chairman), Smith of South Carolina, Kenyon, and Wadsworth.

Senator SMITH of South Carolina (presiding). We have with us this morning two gentlemen from the Navy Department, who will testify as to the processes and also the amount of nitrogen material needed by the Government. One of the gentlemen is a chemist.

The main object that the committee had in view in hearing these gentlemen was to ascertain as nearly as possible the different processes and the one most suited to what we desire here, and also what processes were available for use under the patent law. Some question has been raised here as to a new process in use in Germany.

I would like for you, Mr. Patterson, to give to the committee what knowledge you have of these different processes, and which one, in your opinion, is the proper one, from every standpoint, both as to the product turned out and the cheapness of it.

STATEMENTS OF COMMANDER CHARLES B. McVAY, JR., ASSISTANT CHIEF OF ORDNANCE, NAVY DEPARTMENT; AND MR. G. W. PATTERSON, CHIEF CHEMIST, PROVING GROUND, INDIANHEAD, MD.

Mr. PATTERSON. So far as the literature on this subject is concerned, it is very meager, except in relation to the process used in Norway, and that is known as the arc process, and about what the Germans are using to-day, we have to guess at a great deal.

When you speak of a new process in Germany, I think it simply is an adaptation of one of the processes which has been offered to us by this cyanamid company.

The arc process requires a cheap water power to produce on an economical scale. It can be produced, of course, if you can get electricity, whether it costs money or not, but, while you use from 3 to 5 horsepower for the electric process, the process used by the cyanamid company, and I think by the Germans, would only require about half a horsepower. If we have got plenty of cheap horsepower,

and can control it properly, and it is within the limits of the output which we would need under war conditions, that would be the process to adopt; but, it seems to me that the other type is far better for us because we can set it up anywhere in the country, make our power from coal at any point in the country, place it where we do not have long distances in transportation. Shipping nitric acid, if it has to be done from the west or east coast, is a very expensive proposition. The nitric acid can not be shipped except when it is mixed with sulphuric acid, and that increases your freight rate, because sulphuric acid is really a dead load.

So far as the question of cost is concerned, nobody in this country knows what the German's cost will actually be. They make estimates, but they are the roughest kind, for the reason that no nitric acid has been made under those processes in this country. We can get an approximate, however, on the Norway process—the arc process—when we consider what other things they produce at the same time. The arc process produces not only nitric acid, but it produces nitrate of lime, and also produces nitrites, which have a great sale in the dye trade. Those people make as a principal output fertilizer ingredients; that is, your nitrate of lime; the second one the nitrite of soda, which is used in dye works and finds a ready sale. The nitric acid part of it is a mere by-product with them, because it takes more apparatus, and if they do not convert it, it is a dead loss, and it is simply a by-product, as I consider it.

You take the other system, by which you convert ammonia into nitric acid, and you can get your ammonia in various ways. When you spoke of the new process, I think it is simply the conversion of some form of ammonia, however obtained, either from gas works burning coal, or what you know as the cyanamid process. The cyanamid process is simply a fixation of nitrogen to hydrogen in the form of ammonia, and all combined with lime. They take lime and charcoal and heat it in an electric furnace. That gives them a calcium carbide, very similar to the calcium carbide that is used in making the ordinary acetylene gas, which is used everywhere now. It is, chemically, just a little different; that is, in its physical form; and the way in which it reacts. It is a certain type which they have to produce.

Now, having gotten it in that form and heating it in a current of nitrogen, it takes up nitrogen to form the cyanamid. It is a calcium-nitrogen-hydrogen compound, and ammonium, of course, is nitrogen hydrogen.

Having gotten that compound, they have the material that is used in agriculture. If you want to have your material converted to agricultural purposes your product is right there; there is no other by-product with it. They start from that point to make nitric acid. By treating this fertilizer material, calcium cyanamid, with steam, ammonia is given off, and they get this gaseous ammonia, and by oxidation methods convert it into nitric acid.

You can get your ammonia in other forms; you can get it from gas works, you can get it in various ways, but it is the same ammonia, no matter how you get it, and it is really the starting point for nitric acid. If at one time you want to convert your material into fertilizer material, you would do that; in war times, if you wanted to convert everything into nitric acid or a very large part of your material to

nitric acid, you would have it right in that process, but you could not do it in the other process, as I believe, in any practical way. I think you would have to have it really as a by-product, and have other things formed at the same time, which you would have to get rid of.

The question of cost of conversion of ammonia to nitric acid we know absolutely nothing about from a practical standpoint. We have to take somebody else's say-so. Whatever the Germans publish as to their costs is very meager, and it is, a great deal of it, guess work, but the cyanamid company, I understand, is putting in a plant which they claim will be running at this time an experimental unit for converting the ammonia into nitric acid. They never have done so up to this time, because they did not believe they could compete; that is about the size of it.

Senator WADSWORTH. Where is that plant?

Commander McVAY. It is in Canada, just across the line.

Senator KENYON. That is the plant which has been referred to.

Senator SMITH of South Carolina. That is the one Mr. Washburn told us about.

Senator KENYON. We know about that, if it is that Canadian plant.

Senator SMITH of South Carolina. I would like to have you tell us, Mr. Patterson, if you know, the availability of these processes by this Government. They are under patents, more or less, I suppose. Have you any knowledge about that?

Mr. PATTERSON. I have absolutely no knowledge of their availability.

Senator SMITH of South Carolina. What are the sources from which the Government now obtains its nitric acid in the manufacture of its explosives?

Mr. PATTERSON. From imported Chile saltpeter.

Senator SMITH of South Carolina. There is no other source that you know of?

Mr. PATTERSON. No other source.

Commander McVAY. That is at Niagara Falls on the Canadian side.

Senator SMITH of South Carolina. We have had testimony as to that. It was the opinion of the committee that the Navy Department or the War Department would have exhaustive knowledge of the sources and the processes, and I phoned to Secretary Daniels to send down whatever experts he had, hoping we would get the information, if any such information was available, as to these processes of obtaining this nitric acid by this new process, or processes known as the arc and cyanamid processes, or this new process someone had spoke of as being now used by the Germans.

Senator KENYON. Are there not a number of patents on these processes?

Commander McVAY. Yes, sir.

Mr. PATTERSON. They are all covered by patents.

Senator SMITH of South Carolina. Have either of you any knowledge as to the possibility or practicability of the Government availing itself of these processes?

Commander McVAY. We have had offers to sell processes outright and I imagine every branch of the Government interested has had

some such offers. We have had an offer of sites and the patent rights, either outright or on the royalty basis, but no price has been named yet. In my opinion there would be no difficulty in obtaining the right to use any process; it is simply a question of how much price.

Senator WADSWORTH. Purchased, you mean?

Commander McVAY. Purchase the right to use it or purchase the process outright, more than likely the right to use it on a royalty basis.

Senator SMITH of South Carolina. The basis of all explosives now used is nitric acid, is it not?

Commander McVAY. Yes, sir.

Senator SMITH of South Carolina. With the cutting off of the Chilean supply, we would be absolutely without a supply of nitrogenous products unless we had some process similar to this, would we not?

Commander McVAY. Unless we had a Navy large enough to keep control of the sea.

Senator KENYON. Just suppose we were in war in a week or so, and we were cut off from Chile, what would we do for those products?

Commander McVAY. At first, of course, we would have to exhaust the supply on hand, and then if we were cut off we would have to adopt some such process without regard to cost.

Senator KENYON. The cyanamid process, for instance?

Commander McVAY. With the knowledge I have, I should say that process; but there is one thing in connection with that, gentlemen, in the naval bill this year there is an item which covers a two-year supply of sodium nitrate for Indian Head. We expect to purchase that and store it.

Senator SMITH of South Carolina. Has either yourself or Mr. Patterson knowledge of this process sufficient to warrant you in stating whether or not it is past the experimental stage, this extraction of nitrogen, and is it practically a commercial fact?

Commander McVAY. The only information I have is from the trade journals and particularly the Iron Age, which gives very good information on that subject in the issue of February 10, 1916. This large company, with an immense amount of capital, is turning out cyanamid for fertilizer, and I judge, from the fact it is turning it out, it must be a commercial success, that is, at present.

Senator SMITH of South Carolina. Mr. Patterson, do you know the relative cost of atmospheric nitrogen, and the nitrogen obtained from the Chilean deposits?

Mr. PATTERSON. Why, I can only give you figures that are given us from Norway, when they sell it as a by-product. If you are reselling a by-product you can afford to sell it a good deal cheaper than if you were turning it out for that purpose alone, and I do not believe they could make it for the amount which they state unless it were merely a by-product. I understand it is somewhere in the neighborhood of one-half what it cost for saltpeter nitric acid, about $50 a hundred, and giving somewhere between $90 and $100 a ton for Chile saltpeter nitric acid; and that means cheap water power.

Senator WADSWORTH. I was going to ask whether it is not a very very difficult thing for us to make any comparison with the Norway situation, on account of their remarkably cheap water power?

Mr. PATTERSON. Cheap water power, and knowing how much of the main material, and how much profit they make on their principal material. As I say, I consider it is sold as a by-product, and you can sell a by-product a good deal cheaper if you were otherwise going to lose it.

Senator WADSWORTH. Did you say they are not making nitric acid in that plant on the Canadian side?

Commander MCVAY. They are not, so far as I know, but they expect to. Understand, we have not visited it. It seems to me apropos of these two plants that it would be a very easy matter for either the committee to go or to detail some one to visit the Canadian plant and also this plant in Nitroli, S. C.; that, I understand, is an arc plant.

Senator SMITH of South Carolina. I think that is very small yet.

Senator WADSWORTH. Is that run by water power?

Commander MCVAY. Yes. In all the comparisons of cost we based our figures on a cost of $3 per horsepower year in Norway, and with that horsepower year cost, they can compete and do compete with the foreign saltpeter, along with their other products. That is what we know. If we can get the power at $3 per horsepower a year, there is no reason why we should not compete.

Senator WADSWORTH. The trouble is, Commander, that all the testimony we have had that I have heard before this committee is to the effect that there is no horsepower in the United States that will be lower than $12, and it runs up to $20 and more.

Commander MCVAY. $12 per horsepower year, even now—I mean with the demand and cost of saltpeter—I think that is rather high, under present conditions. There is no question of the cost of nitrate of soda; that, as I understand it, is fixed by the Chilean Government.

Senator SMITH of South Carolina. They have an export duty.

Commander MCVAY. And they sell concessions to mine these beds, and then the Government fixes the price of that nitrate of soda. We have recently called for bids on nitrate of soda delivered at Indianhead, and the lowest bid we got was 3.38 cents a pound, as opposed to a previous average of about 2½ cents.

(At this point Senator Gore entered the committee room and took the chair.)

The CHAIRMAN. I am sorry to be late, but I had another committee to attend.

Senator SMITH of South Carolina. Mr. Chairman, I would like if Mr. Patterson has any additional information that no question we have asked has indicated, that he just state it to us, now that he understands what our object is.

The CHAIRMAN. We would be very glad to have any statement that you care to make, Mr. Patterson.

Senator SMITH of South Carolina. And to know whether or not in his opinion this is a practical system.

Mr. PATTERSON. So far as the practicability is concerned, we have absolutely no reason to believe that it is not in use on the other side. They must be using it; they could not get along without some such process in Germany.

The CHAIRMAN. The material point is whether we are on the edge of a revolution in the matter of producing this material which would

justify delay; if not, the Government ought to go ahead and take the risk.

Mr. PATTERSON. I believe they have their plants in full operation, and have been for over a year producing the nitric acid necessary for their munitions, and we will never be able to do it unless it is experimented with in this country. You have to start something before you will be in a position to jump right into it. It is not something you can build to-morrow and have immediate success with it. You might put up a plant like the one which is in Norway, which is definitely known, and you can obtain all the necessary data on it, but I doubt very much if you can obtain all the data necessary on any of the others which might be used in Germany for the conversion of ammonia into nitric acid.

Senator WADSWORTH. With the aid of coke ovens?

Mr. PATTERSON. With the aid of coke ovens or any other method of producing it from ammonia.

Commander McVAY. Do you not think you could get at that by visiting this plant in Nitroli, South Carolina, using the arc process, and visiting the cyanamid plant, at Niagara Falls?

Mr. PATTERSON. You will find either of those plants are experimental units, which they have got to work out and demonstrate their inefficiencies.

Commander McVAY. The Iron Age says this plant is turning out 2,000,000 pounds.

Mr. PATTERSON. The Norway plant is in practical operation; there is no question about that.

Senator WADSWORTH. You say, then, Commander, to in some way sum up the situation from the military standpoint, that if we were cut off from the Chilean nitrate by war the Navy Department has enough reserve nitrate on hand to carry us over the time in which facilities in this country could be developed for the manufacture of nitric acid?

Commander McVAY. Provided we get the amount asked for under the present appropriation?

Senator WADSWORTH. I am assuming that you get this reserve contemplated in that appropriation.

Commander McVAY. That will give us a two-years' supply at Indianhead.

Senator WADSWORTH. At what rate of consumption?

Commander McVAY. 15,000,000 pounds a year.

Senator SMITH of South Carolina. Upon a war basis or a peace basis?

Commander McVAY. That is our peace basis.

The CHAIRMAN. What is your daily capacity?

Commander McVAY. We expect to turn out 6,000,000 pounds of powder at Indianhead, starting now.

Mr. PATTERSON. Very close to that.

Senator KENYON. What is the cost of powder we purchase?

Commander McVAY. The cost of our manufactured powder is 25 cents a pound; and then in the figuring on the cost of overhead charges, interest charges, pay of officers, indirect overhead of everything that would be counted in a commercial concern, it costs up to-day about 38 cents a pound.

Mr. PATTERSON. About 10 cents for overhead?

Commander McVay. Thirty-four to thirty-five cents a pound.

Senator Kenyon. What did you pay for the product before the Government built the plant?

Commander McVay. Fifty-three cents a pound is what we pay to the outside manufacturers, and that price was established by Congress, after an investigation into the cost of manufacture.

Senator Smith of South Carolina. Before that price was established by Congress, what was it?

Commander McVay. I could not answer that. I think about 80 cents.

Mr. Patterson. We used to pay for smokeless powder $1, then 80 cents, 75 cents, and then right straight on down to 60 cents, and finally 53 cents.

Senator Wadsworth. Has there been that reduction in price generally throughout the trade?

Commander McVay. In powder?

Senator Wadsworth. I mean from a dollar down to 50 cents?

Commander McVay. The cost was a dollar when we first started, and then it has worked down, and we are buying it on down to 60 cents or 75 cents; but the $1 does not represent what we paid for large orders of powder, and at the present time we are not buying any powder from outsiders, but are making all of our powder. There is one outstanding contract.

Senator Smith of South Carolina. You say taking everything into consideration that would be taken in by a commercial plant, your cost is around 35 cents a pound?

Commander McVay. Yes, sir.

Senator Smith of South Carolina. As compared with the outside price fixed by Congress at what price?

Commander McVay. Fifty-three cents.

Senator Smith of South Carolina. And at the price preceding the fixing of the price from 75 cents to $1.

Commander McVay. From 75 cents to $1, depending upon the development of the new industry, the $1 being at the top.

Senator Wadsworth. In other words, Commander, you would not contend that the establishment of the Government plant had brought the price down from $1.

Commander McVay. Oh, no, not from a dollar to 75 cents.

Senator Wadsworth. That was indicated so many times by Senators on the floor that I thought that ought to be brought out. In other words, the industry was in an experimental stage when they were charging a dollar?

Commander McVay. Yes, sir.

Senator Wadsworth. And all have been coming down since, as the process was perfected, to 53 cents?

Commander McVay. Down to 53 cents, which was established as a fair price after investigation of the cost, that is, as compared with our productive cost.

Mr. Patterson. Before the combination of the du Pont and the International, they had three companies, and the bids that came in just before the combination were 69 cents and 70 cents from the two different companies, and that did not include the alcohol which we furnished. Seventy-five cents was the normal price before they were

compelled to reduce it, and the reductions since that time, have all been as the result of the Government powder factory.

Senator KENYON. Then, you are making this powder at 19 cents a pound less than the price the Government has fixed?

Mr. PATTERSON. Yes, sir.

Senator WADSWORTH. And you are making 6,000,000 pounds?

Commander McVAY. Yes, sir.

Senator KENYON. Which would be a saving to the Government in this one matter of $1,140,000?

Commander McVAY. A year.

The CHAIRMAN. How much do you buy from those private concerns in a year?

Commander McVAY. We do not buy any, sir. We make all our own powder now. We have one outstanding contract; when that is completed, we will not, under ordinary conditions, buy it at all.

The CHAIRMAN. When will that contract expire?

Commander McVAY. They are starting manufacture now; it will expire in a few months.

The CHAIRMAN. Then the Government will make all its own powder and divorce itself from the private companies entirely.

Commander McVAY. Yes, sir.

Senator SMITH of South Carolina. You are making this powder out of the ingredients that the Government itself can not make?

Commander McVAY. Yes, sir.

The CHAIRMAN. Did it ever occur to you that manufacture of powder by the Government might shipwreck private industry, destroy these gentlemen who started the enterprise, and amount to socialism?

Commander McVAY. No, sir.

Senator SMITH of South Carolina. It has been the contention of those who have been before us that this process would reduce the price of nitrates. Then having the nitrates produced cheaper by the Government, the price of powder necessarily would be cheaper. If you got your nitrates cheaper out of which you make your explosives, you would make your powder cheaper.

Commander McVAY. Yes, sir, Senator, but there is no change in the price of nitrates.

Senator SMITH of South Carolina. I say, if this process we are now trying to provide for were established and you could get your nitrates cheaper, then your powder would necessarily be cheaper?

Commander McVEY. Would be cheaper, unquestionably.

Senator SMITH of South Carolina. Does it not seem to you that under the demonstration of the Government producing its own powder at this wonderfully reduced cost, when it has to get its raw material in the competitive market or outside its own activities, that if it could provide itself with the processes by which it got this material, it would affect a like reduction in the cost of the powder?

Commander McVAY. It is a question of management pure and simple.

Senator SMITH of South Carolina. You seem to have managed this powder manufacture pretty well. I do not see why you could not manage the other.

Mr. Patterson, is there anything else that you could suggest along the line of inquiry we have been making?

Mr. PATTERSON. I would simply suggest that I would not be too sanguine on this question of cost, to start with. If you can make this material and provide a source for nitric acid, that is your concern more than to make it cheaply. If you can simply make it at the price prevailing in normal times, you can compete, and that is all you have to do. It will work itself after that. You will get all sorts of people going into it, but the point is that this thing has not been started in any way, shape, or fashion. You have to demonstrate it; you have to provide the experimental work necessary on all such things.

The CHAIRMAN. Like the pioneer in any business?

Mr. PATTERSON. You will remember there was an arc plant a few years ago at Niagara Falls. It was somewhat different from the Birkeland-Eyde Norway process, but it was a rank failure commercially; they could not compete. It cost them more, because it took more power and did not give the proper yield, not anywhere near the yield of the Norway process, although they used the arc system, and they made nitric acid directly. It went to the wall.

The CHAIRMAN. In Norway they have immense power.

Commander MCVAY. And they claim by the arc process 60 grams of nitric acid per kilowatt hour. I happened to remember that, because this other concern claims 90 to 110.

Mr. PATTERSON. If you should go into the arc system in this country and have to pay $12 a horsepower you will just about bring your price up to what it would cost to make it from nitrate of soda in normal times.

Senator WADSWORTH. Mr. Patterson, I quoted from very rough memory the testimony already given here about the cost of horsepower in this country. I said from $12 to $20. I do not know whether that is an accurate operation of memory on my part or not.

Mr. PATTERSON. I looked that question up some time ago. In California the Shasta Valley power costs about $16 a kilowatt. A kilowatt is reckoned as 1⅓ horsepower, so that is $12.

Senator WADSWORTH. That is probably the most favorable one, is it not, now operating?

Mr. PATTERSON. Pretty nearly. There are one or two others which run from $16 to $18; I do not know of any less than that.

Senator WADSWORTH. Niagara Falls power is $20 a horsepower, as I remember the testimony here.

Commander MCVAY. You can get testimony from outside manufacturers who actually manufacture the material that we can not give you, because we are not manufacturers under this process. If we were manufacturers, we could tell you exactly what it cost.

The CHAIRMAN. Is the Government manufacturing all the nitric acid it uses?

Commander MCVAY. Yes, sir. We started the first of this month.

The CHAIRMAN. You depend, then, upon the importation for what ingredient?

Commander MCVAY. The nitrate of soda.

The CHAIRMAN. And is the only one?

Commander MCVAY. That is the only one; yes, sir; and that is the base of nitric acid.

The CHAIRMAN. And this process looks to the production of that in this country?

Commander McVAY. Yes, sir, from the air.

The CHAIRMAN. These processes, of course, are all patented?

Commander McVAY. Yes, sir, but we have stated that I do not think we would have any difficulty in getting the right to use the patent, because some have already been offered to us.

The CHAIRMAN. Have you had any research made in regard to the different patents?

Commander McVAY. No, sir; we have not gone into the patent question at all, except the copies of some patents which concerned the production of munitions of war which are furnished to our bureau.

The CHAIRMAN. You mean purely for information and inspection?

Commander McVAY. Information, and we go over them and look at them to see whether it is worth while to go into them.

The CHAIRMAN. Do you care to offer any opinion about the Government reserving the right to use patented articles or patented processes?

Commander McVAY. The Government now has the right to take anything at any time for military necessity.

Senator WADSWORTH. By condemnation.

The CHAIRMAN. The committee will now stand adjourned subject to call.

(Thereupon, at 12 o'clock noon, the committee adjourned to meet at the call of the chairman.)

WITHDRAWAL OF WATER-POWER SITES AND CONSTRUCTION OF WATER-POWER PLANTS FOR MANUFACTURE OF NITRATES.

FRIDAY, MARCH 24, 1916.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met at 10 o'clock a. m., pursuant to adjournment, Senator John F. Shafroth presiding.

Present: Senators Shafroth, Smith of South Carolina, Page, Gronna, Sheppard, Kenyon, Wadsworth, and Johnson.

STATEMENT OF DR. L. H. BAEKELAND, MEMBER OF UNITED STATES NAVAL CONSULTING BOARD, YONKERS, N. Y.

Senator SHAFROTH. I wish you would state your occupation and your profession, Dr. Baekeland.

Dr. BAEKELAND. I am a chemist by profession. I graduated from the University of Ghent, in Belgium, as a doctor of science. I was professor of chemistry and physics at the Government Normal School of Bruges, in Belgium. I was associate professor of chemistry at the University of Ghent, and have been in this country for 27 years. I am an American citizen, since about 20 years. I am the only foreign-born member of the United States Naval Consulting Board, and was appointed by the American Chemical Society and by the American Electro-Chemical Society, two of the societies which were invited by Mr. Daniels to send their representatives.

I am past president of the American Electro-Chemical Society; past president of the American Institute of Chemical Engineers; past president of the Chemists' Club, etc.

I will state that I have recently been awarded the Perkins medal from the chemists of the United States for industrial chemical research, and I have had the Nichols medal, the Willard Gibbs medal, and a few other medals that I do not think would interest you very much.

In so far as my business connections are concerned, I retired from active business when I was 35 years old, on the proceeds of one of my inventions, and since that time I have been a free-lance, except for the fact that I happen to be the president and the controlling stockholder in one of the companies which manufactures one of my recent inventions—a product which is used in electrical manufacture, for insulating purposes. I have no other connections.

Senator KENYON. I think there is no doubt about the doctor's qualifications.

Senator SHAFROTH. You have practically devoted all your life to investigation of such subjects as are before this committee.

Dr. BAEKELAND. I can say that since I have been an adult I have given my exclusive attention to matters of theoretical and applied chemistry; mostly applied chemistry in the later years of my life.

Senator KENYON. You serve on this naval board without compensation, and without even expenses, do you not?

Dr. BAEKELAND. Not only without compensation, but we agreed among ourselves that in so far as we could afford to give our time free of charge for the benefit of the country we could also afford to expend a few extra hundred dollars to pay our expenses and to pay for our stationery, etc., in order to set an example that there are plenty of people in this country willing to do something to pay their debts as citizens, without remuneration, receiving therefor the satisfaction that perhaps they might be of some use.

As a member of the naval board—of the Naval Consulting Board—I have had plenty of opportunity of late of examining the subject of the supply of nitrates for this country. The consulting board is enabled to consider this from the standpoint of national preparedness. This country is in the peculiar condition that, for the purpose of war, we can furnish practically everything that is needed except one thing—nitrates. Now, it so happens that without nitrates, or nitric acid—for practically this means the same thing—there is no possibility of carrying on any war.

I can not better emphasize this than by stating that even Germany with all her numbers of troops and artillery, with all her 42-centimeter guns and her big army and drilled soldiers, could not continue this war if she had no means of making nitric acid from the air.

In times of peace nitric acid is obtained from Chile saltpeter, which is imported from Chile. In the deserts of Chile certain sands contain Chile saltpeter. These sands are washed out and the resultant material is crystalized and separated and sold to the whole world. All countries are dependent upon Chile.

Senator SHAFROTH. Will you please state what are the constituent elements of gunpowder?

Dr. BAEKELAND. Are you referring to black powder or to smokeless powder?

Senator SHAFROTH. Either one.

Dr. BAEKELAND. Black powder is no longer used for war purposes, but probably you refer to smokeless powder?

Senator SHAFROTH. Yes; smokeless powder.

Dr. BAEKELAND. Smokeless powder, and in fact all the explosives which are used in the present war, are obtained from nitric acid, which is made to react on some organic substances. In the case of smokeless powder nitric acid is made to react on cotton. Without cotton, or celluose, in conjunction with nitric acid, it would be impossible to produce smokeless powder. If you make nitric acid react on glycerine you obtain nitroglycerine, which is the base of dynamite; if you make it react on certain products which are contained in coal tar, for instance, toluol, it gives you the explosive of which you have heard so much and which is called trinitrotoluol or T. N. T. In the same way if you react with nitric acid upon carbolic acid, which is obtained from coal tar, you get picric acid. Acting with nitric acid

on one or another of these or similiar substances you get the explosives now used in this new warfare.

This shows the importance of nitric acid. Right at the beginning of the war England saw to it that Germany did not obtain her saltpeter from Chile. Of course, Germany had a limited supply of saltpeter, but Germany was probably not aware that this war was going to last so long. Her supply of saltpeter ran out before long, and so Germany was confronted with the necessity of making her nitric acid by other means. This nitric acid is made by a chemical process, which, I am glad to say, the chemists of the United States can duplicate at any time. There is no particular secret about it, and if the chemists of the United States were confronted with this problem I have no hesitation in saying that, if properly supported and given the necessary time, they would make as good a showing for themselves as did the German chemists.

Senator Smith of South Carolina. How much time would it take, Doctor?

Dr. Baekeland. If we had to prepare ourselves to-day it would probably take from 8 to 12 months before we begin to feel that we were entirely independent for our supply of nitric acid. The Germans have been at it for 18 months. At the beginning of the war the plants for producing this nitric acid were totally insufficient. Of course, Germany had a large supply of ready-made explosives, and besides a large supply of Chile saltpeter. From the conversations I have had with the heads of our Navy Department, I understand that this country has taken the precaution of having a comfortable supply of Chile saltpeter at hand, but this supply, of course, can not last indefinitely and depends entirely on the extent and the duration of any war in which we might be involved.

The present European war is so different from any wars which have occurred heretofore, not only in magnitude of the operations and the size of the armies, but the tremendously increased consumption of explosives. In two instances, the battles of Neuve Chapelle and Loos, in three days more explosives were used than in the whole campaign of 1870. That gives you an idea of how in modern war any stores of Chile saltpeter would be soon exhausted.

This country, just like Germany, can manufacture this nitric acid. It can be done by using the same processes or processes somewhat better adapted to the peculiar conditions in this country, but it will take some time—it may take a year, it may take more, to get in shape; and even then our chemical engineers have to do a lot of hustling.

Senator Smith of South Carolina. Doctor, right at that juncture, is it your opinion that the processes have been sufficiently perfected for them to now be put into practical use?

Dr. Baekeland. Yes, sir.

Senator Kenyon. You think we have had the last word in these processes?

Dr. Baekeland. No, sir. We shall never have the last word. Chemical processes are improved all the time, and what you started three or four months ago, by practice, you will find out how to do much better and much more efficiently. That is one of the characteristics of the chemical industry, that what is good to-day is no longer good enough to-morrow, and with these processes every chemist feels that we are only at the beginning of perfection.

But the processes used to-day in Germany are entirely practical processes. They have not originated entirely in Germany; most of those processes are the result of cooperation of men of several nations, in fact, it may please you to know that the first practical method for making nitric acid from the air was invented and developed right here in the United States by two American electro-chemists, Bradley and Lovejoy. They started a plant at Niagara Falls as far back as 1901. They made the nitric acid from the air by producing the combination of nitrogen and oxygen in the air, under the influence of the electric spark. They had a full unit operating at Niagara Falls. The matter was described at the time, patents were taken out, and the unit was kept in operation for quite a long period, but finally they had to give up the problem, because nitric acid could not be made at remunerative prices, in view of the too high cost of electric current made by water power at Niagara Falls. The electric power at Niagara Falls cost $18 to $20 per horsepower-year, and that is much too high for making nitric acid by such a process profitably. But the Norwegians took up the same process, perfected it further, particularly in view of the fact that Norway could obtain electric current produced by water power at the cost of $6 or $7 per horsepower-year made it worth while building there a tremendous industry, and since that time the Norwegians have been manufacturing from the air a large amount of the nitrates which are used in Europe.

I should mention, however, that the Germans get very little nitrate there, for the reason that that company is under the control of French capital, and the Frenchmen quite naturally have done their very best to withhold the supply from the Germans, but England is being provided, aside from what she imports from Chili, with a considerable amount of the nitrates made in Norway.

The process the Germans are using——

Senator GRONNA. Doctor, would it disturb you for me to ask you a question right there? The Birkeland-Eyde process is, however, an inferior process, is it not, to what is known as the cyanamid process?

Dr. BAEKELAND. It is rather difficult to say yes or no, in a general way. The process is inferior from the standpoint of power required; that is to say, for making one ton of nitric acid with the Norway process, which you mention, it requires about five times as much power as it requires to make a ton of nitrate acid a year with the processes which I was about to describe. In every case where water power is scarce or expensive it is undoubtedly inferior.

Senator GRONNA. I meant it is more expensive?

Senator SMITH of South Carolina. Doctor, what constitutes the difference in cost of water power as between Norway and the United States?

Dr. BAEKELAND. Well, sir, there are several factors which enter into this question. It is always a question, first of all, of demand and supply. It so happens that in this country there is a considerable demand for water power, and people who have water power try to sell it at their own price. Take, for instance, Niagara Falls. On the American side you have to pay $18 or $20 per horsepower-year, while on the Canadian side you get your horsepower for 10.50.

Senator KENYON. Why is that?

Dr. BAEKELAND. First of all, the Canadians, when they built that power plant, had the advantage of all the practical experience which

had to be gathered in the United States in the construction and in the operation of water powers; and, second, the demand in Canada is considerably less because the industrial development of that country is not in such an advanced stage as it is in the United States.

Senator KENYON. Doctor, you said last night in your lecture that the water power at Niagara Falls could be used to make fertilizer that would make a difference of 3,000,000 bushels of wheat per day in this country. That rather startled me.

Dr. BAEKELAND. Mr. Tome, the former vice president of the American Electro-Chemical Society, who is one of the best known electrochemical engineers, a short time ago went to the trouble of calculating what the power of Niagara Falls would mean in increased production of wheat if the power were used entirely for the manufacture of nitrates or nitrogen products for fertilizer. Taking the rate of increase of the wheat yields by the use of increasing amounts of nitrogen fertilizer, as determined by the agricultural experiments in Europe and in this country, he came to the remarkable conclusion that the full power of Niagara Falls, were it used to transform the nitrogen of the air into cheap fertilizers, would mean an increase in the wheat crop of this country of 3,000,000 bushels every 24 hours.

Senator SMITH of South Carolina. What is your knowledge of the cost of fertilizers produced by this process, as compared with the means that we have of obtaining fertilizer now?

Senator PAGE. Senator, just one moment, before you pass to that: Doctor, will you please explain to us why the power on the Canadian side may not be transmitted to the American side?

Dr. BAEKELAND. It is being transmitted to our side.

Senator PAGE. You say it is worth $10.50 on the Canadian side and $18 to $20 on the American side? Why is that difference, if there is no law which prevents the power being transmitted?

Dr. BAEKELAND. On the Canadian side they lease power under special contracts. I am referring to the special lease of power to the Cyanamid Co., which obtains its power at the rate of $10.50.

Senator PAGE. If they were to make a contract now would not they receive a price substantially the same as on the American side?

Dr. BAEKELAND. As to the price of the Cyanamid Co., the fact is that now you would have to pay a higher price, and I know by experience if you were to obtain the same power on the American side you have to pay considerably more for the cost of transmission.

Senator PAGE. Why does not the law of supply and demand govern? If there was a greater demand to transmit the power across the river there, what is the objection to transmitting it and making it available for use where it is most valuable?

Dr. BAEKELAND. That is under consideration, but most electrochemical installations require the investment of many millons of dollars, and I understand that the present situation of imported current is unusually shaky as far as the steadiness of the transmission of the power from the Canadian side is concerned. Nowadays it is practically impossible to buy a large amount of power at all in Niagara Falls, and I know some people who were inclined to establish a factory there operated by imported current until they realized that in 24 hours the power from Canada may be shut off and then they could not get anything.

Senator Smith of South Carolina. I would like to ask another question right in this connection: Your contention, is, therefore, that on account of the great demand for power in this country they can get a better price and do get it?

Dr. Baekeland. That is right.

Senator Wadsworth. Mr. Chairman, I might add just a little—not in the line of a witness—but just a little information of the matter of the Niagara Falls power situation.

The biggest plants on the Canadian side, according to my information, have been sending a large part of their power across the river into the United States and selling it, as the doctor has said; but, also from my information, the Canadian Government in granting those companies—which are largely American capital—charters to operate on the Canadian side established some hold over them in this respect, that if Canadian communities, municipalities in particular, need that power the companies operating and manufacturing power on the Canadian side must supply them first.

Senator Page. At a named price?

Senator Wadsworth. I would not say that; I think so, but I am not certain. At any rate, the Canadian communities have very naturally been growing up in that vicinity; and the Canadian Government, as I understand it, and the governments of those municipalities have been calling upon those power companies on the Canadian side for more and more of their power. The output of the power is limited by a treaty with the United States, and the result is that the manufacturers on the American side who have been in a large degree dependent on power brought across the river on the wire are finding themselves confronted with the proposition that they are going to be cut off, choked off, slowly but surely; and that is one of the reasons why the development on the United States side of the great industries there—and it is an enormous industrial development that has been going on there the last 10 or 15 years—has come to a halt. It has come to a halt to the extent that at 4 or 5 o'clock in the afternoon a lot of the big industries dependent on electric current for running their plants have to stop, in order that the cities of Niagara Falls and Lockport and Rochester, where the trolleys are run, 70 miles away, and Syracuse, 150 miles away, where the trolleys are run by this same power—in order that those cities may get their lighting, the peak of the load being about 5 or 6 or 7 o'clock in the afternoon for municipal purposes, and when the peak of the load arrives the factories have to close. It is really a very serious situation, and we suffer and Canada does not.

Senator Smith of South Carolina. I would like to hear you, Doctor, on the production of nitrogenous fertilizer from this process, as compared with the cost of getting it otherwise now in America.

Dr. Baekeland. Getting it where?

Senator Smith of South Carolina. What, in your opinion, would be the benefits in this country by using this process to produce fertilizers as compared with the prices we have to pay now through the means of getting our fertilizers now?

Dr. Baekeland. As I stated, the problem of supplying this country with nitrates or nitric acid, in case of war—if it has to be done regardless of cost—is a relatively simple problem. It can be done. The fact that the Germans did it shows that it can be done. The

question of supplying the country with nitrates or nitrogen fertilizers for peace purposes is a totally different problem, because it is not only a question of making those products, but of making them at such a sufficiently low price that the farmer can afford to use them.

Last evening in my talk on the subject I gave an example with which I am familiar, because it relates to the country where I was born—Flanders, in Belgium. You have probably heard it stated, repeatedly, that the yield per acre in Germany is considerably more than the yield per acre in the United States. That is true. Ordinarily people do not know that the yield per acre in Belgium is still higher than it is in Germany, and it is very significant that Belgium uses more nitrogenous fertilizer than Germany. It is still more significant that the yield per acre for most of those crops is almost proportionate, within certain limits, to the amount of nitrogen fertilizer consumed; in fact, those limits do not seem to have been reached, from the fact that fertilizer costs money and naturally there arrives a point where it does not pay the farmer to use more fertilizer. As soon as you cheapen the cost of fertilizer you give the farmer a chance to realize upon the result of his labors by increasing his yields per acre. If this matter is important in countries like Belgium and Germany, where farm labor is incomparably cheaper than it is in the United States, it is almost self-evident that the matter becomes much more important in a country like the United States where farm labor is scarce and expensive.

I am told that the reason our farmers do not use more nitrogen fertilizers is that they have to pay too high prices for it. The same conditions used to exist in Belgium. When I was a young man there I remember some people who became very wealthy by selling to the poor farmers sand which they had made to smell like guano by adding a little guano to it. [Laughter.] Then the farmers began to realize that it would be well to analyze their fertilizers, and so they got chemists to do this.

Senator SMITH of South Carolina. We had the same experience in South Carolina.

Dr. BAEKELAND. And then after a while the Government organized agricultural stations copied from the agricultural stations in the United States, which since then have been copied all over Europe, and these began to attend to the chemical analysis of fertilizers. Then the farmers began to realize that the only way for obtaining their fertilizers cheaply was to start cooperative societies, and then they did away with a lot of middlemen and they were getting their nitrogen fertilizer considerably cheaper delivered to the consumer than it is obtained in the United States. I am told, however, by several of my friends who are acquainted with the commercial situation that the freights here in the United States, the remixing of fertilizers, and the middlemen constitute extra charges, so that finally when the fertilizer gets into the hands of the farmer he has to pay considerably more.

The statement is made by the present Government monopoly in Germany that after the war is over and after what they know now about the synthetic manufacture of nitrogenous fertilizer from the air, after all the experience they have acquired during this war while making nitric acid, that they will be in such condition that

they intend to furnish to the farmers of Germany nitrogen fertilizer at about one-half the price it is costing the consumer here in the United States. If Germany can do that, gentlemen, there is not the slightest doubt in my mind that we can do the same here or that we can do better.

Senator SMITH of South Carolina. Doctor, at the present time what would you say it would cost to produce a ton of the nitrates under the cyanamid process as compared with the cost of Chilean nitrate?

Dr. BAEKELAND. I had the data before me on the Naval Consulting Board, but I do not remember them. But even to-day it might be profitable to oxidize ammonia obtained from any source and make nitric acid from it and get it somewhat cheaper than it costs now to make nitric acid by starting directly from Chilean saltpeter. This is due mainly to the increased price brought about by the extraordinary war conditions which are existing now.

Senator KENYON. Doctor, is taking all of this nitrate out of the air going to have any effect on the nitrogen required for human life? [Laughter.]

Dr. BAEKELAND. It is less than a drop in the ocean. To give you some idea of that, a square mile of atmosphere, full depth, contains enough nitrogen to keep our generation supplied, and there are a good many square miles of it.

This quest or struggle for nitrogen is one of the tragedies of the human race. It is staggering to think that here we are with all our knowledge of all that we can accomplish, knowing what can be accomplished by the aid of science, and that still there should be an insufficient production of food. When you begin to imagine that our so-called overcrowded population of the world, which, after all, only amounts to 1,500,000,000 inhabitants, as far as statistics go, could be placed comfortably on that little bit of spot of the earth which is called Lake Champlain. If you will make the calculation, you will find there is standing room for everybody on the frozen surface of Lake Champlain, although some parts of the world are overpopulated and some nations of the earth prefer to fight and try to steal other countries in order to have more elbow room. If you imagine, furthermore, that in wintertime, if Lake Champlain were frozen over, and if the very old people and the very young people were to stand aside, there would be about as much skating space for the population of the earth as there is in New York Central Park on the pond on a busy winter day.

The whole situation is a shame to the human race. We know how to get nitrogen from the air; we know how to increase the yields of our acres. We do not do it, although those chemical processes are no longer secrets, and we know all about them. The key to the whole situation is better utilization of our natural resources of cheap power. If you make your nitrogen compounds or your nitric acid at too high prices, you may be able to use it in war time—in war time nothing is too expensive when it comes to murdering each other. For instance, carbolic acid, which in times of peace can be purchased at 7 cents a pound, is frequently considered too expensive for surgical purposes or as an antiseptic, but in war times at $1.75 it is not too expensive when it comes to converting it into picric acid for explosives.

The question of the fixation of nitrogen from the air from the chemical standpoint is clear and easy, and is a problem no more difficult than any other chemical problem. But it becomes impossible from the standpoint of peace production for cheap fertilizers unless you can utilize in this country our cheap water power.

Senator PAGE. Doctor, will you tell us what you think the maximum price will be at which we must discontinue the making of nitrogen from the atmosphere? Can we run at $15 a horsepower and do it?

Dr. BAEKELAND. Some people say that $15 per horsepower would be a price at which it could be used, but the price of the fertilizer would certainly be higher than what you can get for $10.50 on the Canadian side; and $10.50 is considered at the present time too high. I am told that the price should not be over $7 or $8.

Of course, this involves detailed calculations, and commercial considerations, which are very intricate. Such men as Frank Washburn and his assistants and chemists, who have devoted a lot of time to the subject, know better than I do how the situation stands in this country. What I am giving you is merely a general statement. It can be done with a $6 or $7 horsepower, because it is being done in Norway; it can be done at $10.50 per horsepower, because it is being done on the Canadian side of Niagara Falls.

Senator GRONNA. Can you give the price of saltpeter per ton or per 100 pounds in Norway?

Dr. BAEKELAND. I could not give you those figures. I could furnish them to the committee; but I will say that prices of saltpeter have gone up tremendously. All the chemical prices nowadays have increased in the most absurd way in many cases—ten times, twenty times——

Senator GRONNA. Pardon me, I mean in times of peace; I did not mean, of course, just now. Have you any idea what the cost of production is in normal times?

Dr. BAEKELAND. The cost of production?

Senator GRONNA. The cost of the production of the nitrates.

Dr. BAEKELAND. No; these matters are carefully guarded secrets, and we only know what leaks out.

Senator GRONNA. Do you know what it is being sold for?

Dr. BAEKELAND. It is sold in successful competition with the Chile saltpeter imported from Chile. Of course, the price of Chilean saltpeter is regulated first by the cost of production, the profit thereon, and also the export tax. The Government of Chile charges upon every ton of saltpeter which leaves the country an export tax, and the Chilean Government has been using this tax for building up a large strategic railroad line which parallels the coast, and of which you have probably heard.

Senator PAGE. What is the amount of that export tax, if you know?

Dr. BAEKELAND. I do not know, but I could get you all those details.

Senator SHEPPARD. Is not the solution of that the Government operation on public lands of manufacturing plants or those products so that private profit would be abolished, and then we would get the cheapest possible rate?

Dr. BAEKELAND. That would be one way of solving the problem of our unfortunate situation, but this country up until now does not

seem to have grown up to the condition where it can run as profitably as a private enterprise such a vast project.

Senator KENYON. We are making powder very successfully.

Senator SHEPPARD. Very successfully, and we have brought down the price of it.

Dr. BAEKELAND. Yes, sir; and by and by, after the experts of this country have a little more to do with these matters than our lawyers——

Senator KENYON. "Politicians," you said last night?

Dr. BAEKELAND. Yes; we may come to a condition where a project of this kind can be run as efficiently as the Panama Canal. I am not one of those who systematically says that whatever the Government does is no good, and whatever private enterprise does is good. We have many private enterprises which have been mishandled and wrecked.

Senator SHEPPARD. If private enterprise handles it, they will charge all the traffic will bear; they are in it for the profit; they will always exact the highest price.

Dr. BAEKELAND. At the same time they will have to hustle to face competition and keep on improving.

Senator SHEPPARD. But, understand, in this country they are smooth enough to avoid competition and monopolize and charge their own price.

Senator PAGE. Doctor, please explain to us why it should ever come to be a fact that we should be compelled to sell this power or utilize this water power for agricultural purposes, when perhaps for the purposes of blasting out granite and marble it will demand twice the price? Why should not this power be sold where it will bring the most? Why should not the law of supply and demand govern?

Dr. BAEKELAND. It seems natural.

As I told you, in Germany they are preparing themselves for utilizing the acquired experience of the war for the benefit of their economic organization by making themselves still more self-contained and more independent from other countries by raising the yield of crops on the relatively few acres they have in Germany.

There are two points of view, however, in this matter, the purely commercial standpoint, and then the strategic standpoint in time of war. There is also what I would call economic strategy; it is a mighty good thing for a country to make itself totally independent of any other country, and I believe if there is any country which can accomplish this it is the United States, on account of its extent and the unusual variety of its natural resources.

Senator PAGE. I do not want to admit that Vermont is not as good an agricultural State as Iowa, but for all that I can not see why if the power exist here that it should not be applied to those purposes for which it is worth the most. If it is worth more for mining and quarrying, let it used for mining and quarrying or manufacturing, and I do not know what my friend Kenyon would say about applying it.

Senator KENYON. My attention for the moment was distracted.

Senator PAGE. Why should we assume that the water power of this country should not be utilized for the purposes of supplying that demand which can afford to pay the most for it?

Senator KENYON. Water power in this country, according to the reports of the Secretary of Agriculture, seems to be all in the hands of monopolists.

Senator GRONNA. According to the statements of the witnesses who appeared before you, there is but very little water power in the United States. We had one witness who testified before this committee a few days ago who said that there were only two places available for water-power sites, that was one at Muscle Shoals and at Priest Falls out in the State of Washington.

Senator WADSWORTH. That was for this one purpose of manufacturing cyanamid?

Senator GRONNA. Yes.

Dr. BAEKELAND. In answer to the question just raised, why should this country not make mainly nitrates for explosives which command a higher price, I should like to call attention to the fact that the market for explosives is a limited market, while the market for fertilizers is practically unlimited, and that is where the question of prices comes into play. The market for explosives is only a small market as compared with the market for fertilizers.

Senator SMITH of South Carolina. Doctor, you mentioned a moment ago the fact that in times of peace we should prepare ourselves strategically as well as otherwise. You mean to say that it would be, in your judgment, wise for this country to put itself in a position to supply itself with whatever is needed, even though it may not use it, for the effect it would have on the supplies from abroad; you mean to say that if we are prepared to produce nitrogen we would be in a position that when extortionate prices or unfortunate circumstances arose prepare to supply ourselves?

Dr. BAEKELAND. I believe, that without going to those extremes, the idea can be carried out simply by having at least one plant in the United States where we are manufacturing our nitrates, and let the future decide how far we are going to extend it afterwards.

I believe that 10 years from now nitrates will be produced considerably cheaper than they are to-day. We are just at the beginning of the art. In fact, it is the history of chemical processes that you need to have at least 10 years of experimental and manufacturing experience and all the incidental knowledge that you can acquire while manufacturing and in the meantime the process grows so fast in efficiency and in output that its own father would not recognize it after 10 years.

Senator GRONNA. What is the minimum amount of power that can be economically used in the manufacture of nitrates?

Dr. BAEKELAND. That is another question, and an important question. These plants have to be run at the utmost efficiency in order to be profitable. You can not make a haphazard installation, and you can not run a small plant of that kind profitably. And that is one of the answers to those who are all the time saying that there are so many water powers available for instance in Maine; I know some of those water powers. You need a good and substantial installation to make it worth while; you must be able to run economically in order to make some profit at the end of the year; and I should say that for the manufacture of nitric acid or cyanamid it

would be rather awkward to try to make a profitable installation on a small scale. It would not take less than, say, twenty-five or fifty thousand horsepower, and it would be much better if there could be available 150,000 horsepower or more.

In Sweden and Norway they have been able to concentrate their plants near large water powers and they have been able to run several hundred thousand horsepower under the same supervision and under practically the same units.

Senator GRONNA. How much horsepower would be required for using the arc process? I mean, the minimum?

Dr. BAEKELAND. Germany now is making nitric acid for munitions at the staggering rate of almost 300,000 tons a year—almost a thousand tons every working day. If that had to be furnished by the arc process, or the Norway process, to which you have referred, it would require a plant of about 900,000 horsepower.

Senator GRONNA. In one plant, you mean?

Dr. BAEKELAND. Or several plants. It would require so much horsepower, because it requires about 3 horsepower per ton of nitric acid per year. If you use the cyanamid method it takes somewhat over a half a horsepower per year. So that you can turn out about five times as much with the same amount of horsepower. That does not mean to say that it is cheaper to use the cyanamid process. That depends on too many other conditions which may very in each instance.

Senator GRONNA. Supposing we should find it to be too expensive to manufacture nitrates from the air. What would you say about the possibility of making nitrates from kelp?

Dr. BAEKELAND. Potash?

Senator GRONNA. I did not mean nitrates: I meant fertilizer.

Dr. BAEKELAND. You are speaking about two different things, as if you were speaking about hats and shoes. You need both hats and shoes, but you can not use your shoes on your head, and you can not put your hat on your feet. When you manufactured fertilizers you need a certain amount of potash, a certain amount of phosphates, and a certain amount of nitrogen.

Senator GRONNA. I understand that kelp contains about 16 per cent of potash and about 2 per cent of nitrogen, does it not? That is the chemical analysis?

Dr. BAEKELAND. This amount of nitrogen is rather trivial.

Senator GRONNA. It does contain nitrogen, does it not?

Dr. BAEKELAND. Most plants contain some nitrogen.

Senator GRONNA. I simply ask you for information if it would be possible to make this product from kelp?

Dr. BAEKELAND. Nitrogen fertilizer?

Senator GRONNA. Yes.

Dr. BAEKELAND. Oh, if you are willing to pay the price it can be done. All these things can be done, but they may cost you fifty times as much as any other process.

Senator GRONNA. The reason I asked you that question is this: We appropriate every year something for experimentation with the manufacture of kelp into potash and into other acids; but you think it would be too expensive?

Dr. BAEKELAND. For nitrogen fertilizer, yes; but as a potash supply the matter has been gone into in a very thorough way by our Department of Agriculture, and some splendid work has been done in that direction. I have read the reports of that department and, from the result of that work, it seems that as a last resort, if you are willing to pay the price, we have an abundant source of supply of potassium salts here in this country. But the subject of to-day refers more particularly to nitrogen fertilizers, which have nothing to do with potassium salts except that they are fertilizers.

Senator SMITH of South Carolina. From your experience, or from your knowledge of the conditions in this country, have we not sufficient water power, privately and publicly owned, to produce all the nitrogen we need, regardless of the cost? I am not talking about the cost; but we have sufficient water power throughout the country, pretty well distributed?

Dr. BAEKELAND. I have not a doubt about that, but unfortunately when the Lord made the United States he put some of those water powers at places where you would not want them as a gift, when you have those water powers way off on the Pacific coast or in Alaska or in Oregon and Washington until that part of our country gets more developed. In the meantime, they might just as well be in the moon. A short time ago I called attention to the fact that some of those water powers which are available there would be less practicable to use than the water powers in Iceland, because the transportation to available markets by means of cheap bottoms from Iceland is cheaper than for the transportation by rail of the manufactured product from the extreme Pacific coast to the East, for instance.

Senator SMITH of South Carolina. Down through the Appalachian chain of mountains there are waterfalls sufficient, if properly utilized, for this purpose, are there not?

Dr. BAEKELAND. Yes; that is all a question of cost. If you want to make nitric acid, regardless of cost, you need no water power whatsoever. In fact, Germany is getting along without water power.

Senator WADSWORTH. I was going to ask you something about that, if you could tell us about how they are harnessing up their coke ovens and deriving power sufficient to make nitric acid by that means.

Dr. BAEKELAND. Germany began in the same way as we ought to do, in case we should be called upon to defend this country. Germany began along the lines of least resistance; began by commandeering some power plants—municipal power plants and steam power plants—and began installing dynamos and erecting new power plants deriving their power from steam or internal-combustion engines, and began to manufacture electric current in increasing amounts. I might mention that if you get coal at about $1.25 a ton, good steam coal, you can make your horsepower cheaper than you would have to pay for it at Niagara Falls. That gives you some idea how the situation stands. The reason manufacturers still prefer to use Niagara power is that they say, "Never mind; the customer will pay for it, anyhow, and we are near our best market and we don't have to be bothered with the problem of power generation or to go to the trouble of having an expensive power installation."

Germany is producing now, about at the rate of 10,000 tons a year, some nitric acid obtained from water powers. I suppose that some

of the water powers over in Austria and the Austrian Alps are being used, but this would be a relatively small amount. The main bulk of the production of nitric acid in Germany is obtained by power produced by means of steam or gas engines and dynamos in the usual way in which such power stations are run here.

Senator WADSWORTH. That is done at a vastly increased cost?

Dr. BAEKELAND. I do not know, sir; but from the way they have been spending millions and millions I suppose cost plays a very small rôle. Germany has spent over a hundred million dollars in installations since the beginning of the war, only for the production of nitric acid, availing herself of what existed before and adding extra equipment.

Senator SHAFROTH. It includes both that which is generated by steam and that which is generated by water power?

Dr. BAEKELAND. That includes, so far as figures have been communicated to me, the experiments which have been made to make Germany independent of Chile, and includes all the plants which have been erected since the war started—$100,000,000.

Senator WADSWORTH. Prior to the war did the German Government actively participate in the manufacture of nitric acid and fertilizer itself?

Dr. BAEKELAND. No, sir; as far as I know they have encouraged by subsidies and in every way the chemists and engineers who were busy with the problem. That is one of the methods of Germany—rather an un-American method, the paying of high subsidies to private manufacturers—so as to let them go to the risk of starting new processes. The best example has been the manufacture of one of the excellent gasoline motors for flying machines which they have in Germany. An automobile manufacturer has received over a million dollars in subsidies from his Government for preliminary experimental work in helping to devise a motor which could stand the "racket." And a similar method of attacking a problem has been followed by the German Government in the development of the methods of manufacturing nitric acid from the air.

(Whereupon, at 12.02 o'clock p. m., the committee adjourned, subject to the call of the chairman.)

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